GAS TURBINE

July - August 1961

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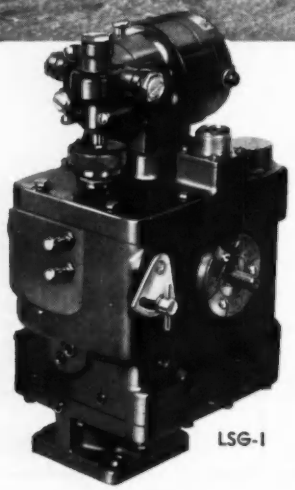
Status Report:

SOLID-FUEL GAS TURBINE PLANTS...

From Kwajalein to Greenland...

...WOODWARD LSG GOVERNORS keep U.S. Defenses on the alert!



LSG-1

Woodward LSG load and speed sensing Governors are meeting the critical power control requirements at U. S. defense installations both here and abroad. Diesel engines driving the generators that supply power for the electronic computers and data processing equipment at missile launching sites, SAGE bases, DEW and BMEW radar stations are under complete and dependable Woodward Governor Control. The LSG combines the rapid response of electric load sensing with the reliability of conventional speed governing — this in a unique arrangement assuring continued satisfactory performance even in the unlikely event of failure of the load sensing circuitry. Governor response is so rapid that, on most diesel engines, the fuel pumps are in a changed position before the next cylinder has received its charge of fuel.

LSG-10

The reliability and ease of operation that has characterized Woodward Governors for over 90 years can benefit your engine or turbine installation too. Write today for complete information about the new Woodward LSG Governors.

D-104

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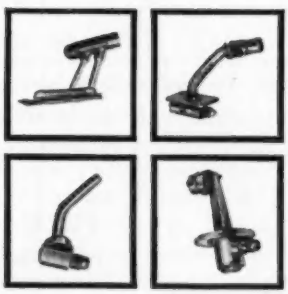
B-58 BREAKS SPEED RECORDS WITH HELP OF BENDIX® FUEL NOZZLES

FLYING A CLOSED COURSE of 1,000 kilometers, a Strategic Air Command Convair B-58 Hustler recently set new world speed records. With full afterburning, the Hustler achieved a top speed of 1,430 mph on its way to a record 1,284.73 average. Each of the Hustler's four General Electric J79-5 engines is fed by 10 Bendix Fuel Nozzles.

Bendix Fuel Nozzles provide dependable fuel delivery to the engines of military and commercial aircraft—answer the more severe problems of cold engine starts and restarts after flameout. Designed and mass-produced to precision standards, they are specified for reliable and economical performance on jet aircraft, missiles, helicopters, and auxiliary power units. Perhaps Bendix nozzles can help solve *your* fueling problems. Write for details.



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Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N.Y.

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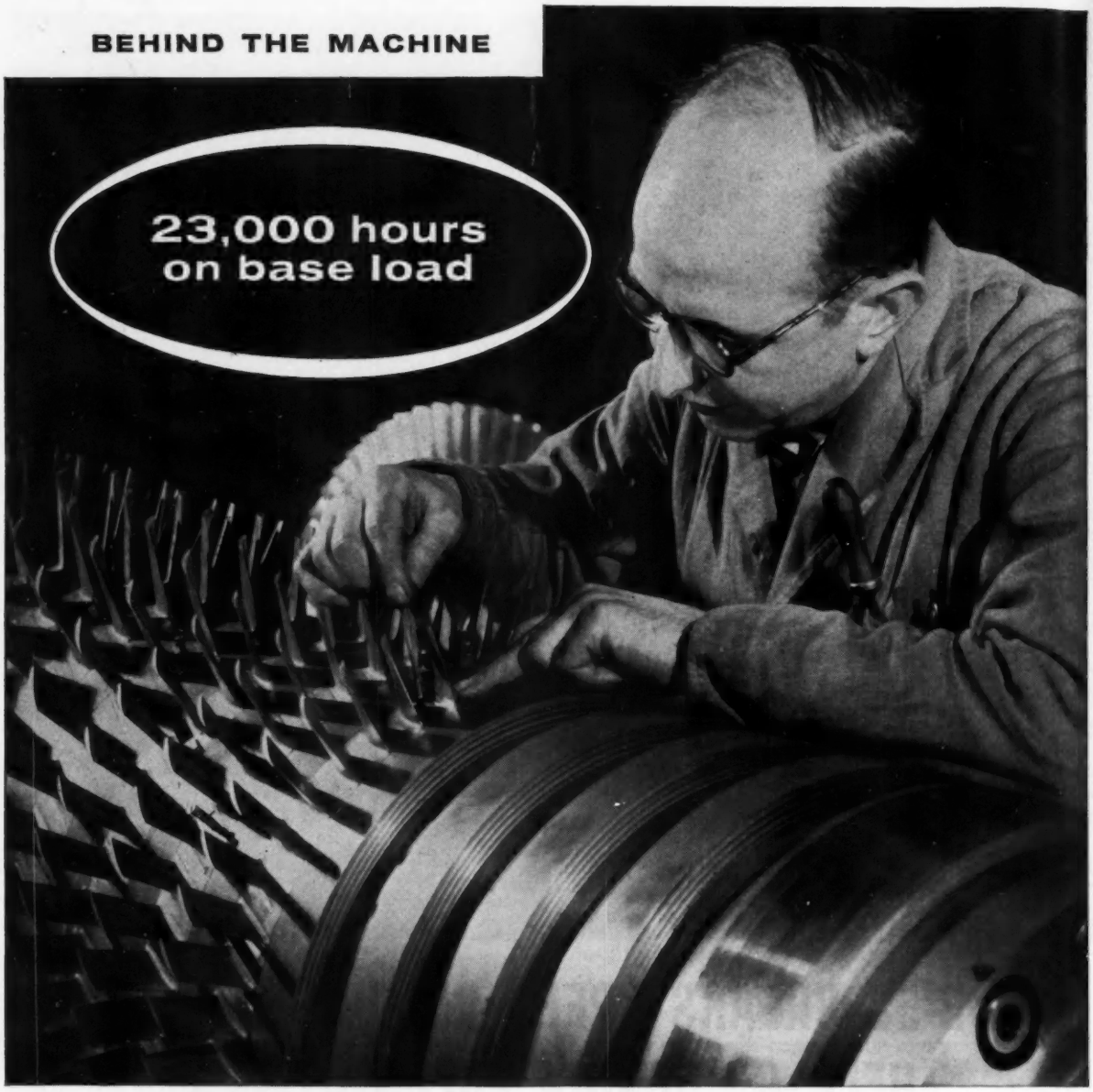
BEHIND THE MACHINE



The proved reliability of AEI industrial gas turbines is typified by a machine in Venezuela which has recently completed 23,000 hours running on base load. AEI makes a range of industrial gas turbines with ratings from 1,750 kW upwards designed to run on gaseous or liquid fuels.

The picture shows work on the compressor rotor of L2IC gas turbines being built, at the AEI Turbine-Generator Division Factory for the Basrah Petroleum Co. These feature a single shaft design which ensures stable regulation and makes them particularly suitable for parallel operation with other generating equipment.

This is a product of AEI Turbine-Generator Division, Britain's largest manufacturer of Turbine-Generators.

AEI **Associated Electrical Industries Export Ltd**
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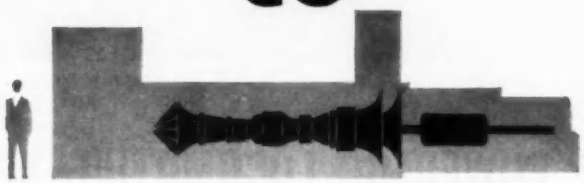
Jet power comes down to earth



PRATT & WHITNEY AIRCRAFT'S NEW TURBOJET POWER PAC OFFERS ECONOMICAL, DEPENDABLE POWER FOR A WIDE RANGE OF INDUSTRIAL APPLICATIONS.

One good example is the Pratt & Whitney Aircraft 10,000 KW Turbojet Power Pac. This is a complete, packaged plant to generate electrical power for peaking, end-of-line, and emergency stand-by. It offers remarkable compactness and operating simplicity with demonstrated thermal efficiency of 25%. And it can be put into operation unattended in two minutes.

For other industries, Turbojet Power Pacs offer similar cost and operating advantages. Applications include low-cost, dependable power for product pipe lines, chemical processing, central air conditioning, mobile power units for emergency or temporary needs, marine propulsion, and earth movers. Units are now available to meet power needs from 2,500 HP to 15,000 HP.

The heart of every Turbojet Power Pac is Pratt & Whitney Aircraft's axial flow turbojet engine, backed by 13 years of engineering development. With over 20,000 units produced, its reliability and durability have been proved in 15,000,000 hours of operation.

A representative of Pratt & Whitney Aircraft's Industrial Power Department will gladly discuss the application of the Turbojet Power Pac to your individual requirements. For more data, write or wire:

Industrial Power Department
Pratt & Whitney Aircraft
Division of **UNITED AIRCRAFT CORPORATION**
East Hartford 8, Connecticut

For more information write in No. 704

Union Pacific's new and mighty locomotive crests Sherman Hill, Wyoming, with a heavy load.

WORLD'S MOST POWERFUL LOCOMOTIVE SPEEDS FREIGHT ECONOMICALLY WITH BENDIX FUEL AND IGNITION SYSTEMS

This is the world's mightiest self-powered locomotive at work. On level track, it can pull 735 fully loaded freight cars—a train more than seven miles long! Its two engines—an auxiliary diesel engine and a gas-turbine power plant—depend on Bendix fuel injection and ignition systems to help keep its mighty power flowing smoothly and efficiently.

This new gas turbine-electric locomotive, built by General Electric for Union Pacific, is designed to haul freight faster and more economically. It burns less expensive "residual" fuel—a thick, viscous substance with a heavy tar content which must be heated before it will flow freely.

The Bendix ignition system fires this low-volatile fuel as efficiently as volatile gasoline is ignited in your automobile engine. The Bendix fuel injection system is used in the auxiliary diesel engine, which also furnishes power for "yard" movement of the locomotive.

General Electric has been an important builder of locomotives for more than 65 years. To be selected as the supplier of fuel injection and ignition equipment by G.E. for the mightiest locomotive they have ever built, is truly one of the finest tributes that could be paid to the all around efficiency of Bendix equipment.

It is equally impressive that whenever exceptional performance, complete dependability and operating economy are the requirements, diesel engine manufacturers in increasing numbers are turning to Bendix for their fuel injection and ignition requirements.

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For more information write in No. 705

GAS TURBINE MAGAZINE . . . *incorporating gas turbine power*

GAS TURBINE

VOLUME 2, No. 4, July-August, 1961

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editorial

Sales and Service 7

articles

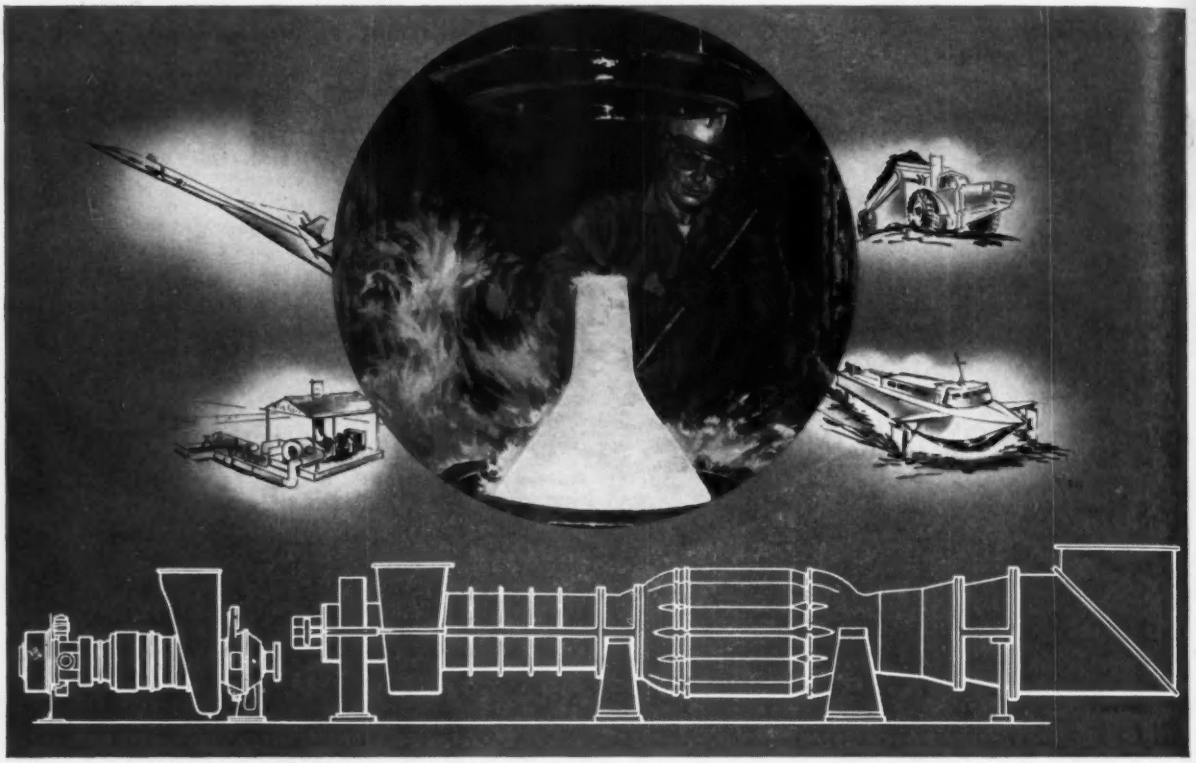
Special Automotive Section:

Austin's 250-hp Industrial Turbine 18
Turbine-Powered Trucks Take to the Road 19
Power for Campbell's "Bluebird"—4100-hp! 21
Rover Gas Turbines Ltd. 22
Chrysler's Automotive Turbine 23

Solid-Fuel Gas-Turbine Plants 24
Power for "Flying" 80-ton Hydrofoil 27
Big Gas Turbine Installations 30
Gas Turbine-Powered "Power Package" 33

departments

Hot Line 9
Industry News 10
Contracts & Procurements 12
Coming Events 13
People, Plants, Places 16
Product News 34
Patents 36
Readers Service Card 37
Technical Briefs 40
Product Technical File 41
Advertisers Index 42



Turbine Forgings Unlimited

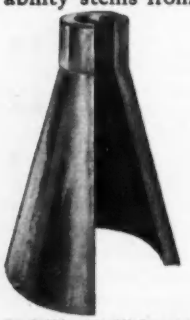
Few prime power sources depend so completely on part integrity for reliable performance as the gas turbine. Its extremes of temperature, rotating speed and imposed stress demand a level of metallurgical soundness available only in closed impression die forgings.

This is as true of workaday turbines—serving in the growing list of stationary, propulsion and auxiliary power applications—as for the most critical military designs. In each, dependability stems from component stamina.

EST. 1883

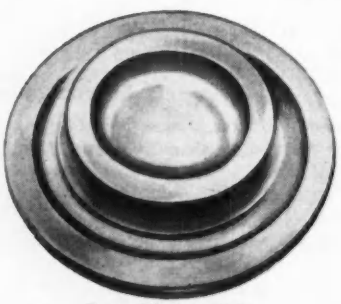
No other process approaches forging for optimum development of required properties, refinement in structure and precise control of flow characteristics. None combines high ultimate strength with comparable ductility to combat severe and sustained shock load.

Experienced leader in Automotive, Aircraft, Missile, Nuclear and Turbine fields, Wyman-Gordon is well prepared to meet your complete forging requirements. For one turbine forging—or thousands—contact Product Manager, Turbine Applications.



Length 22"; weight, 190 lb.; material, nickel-base, high-temperature alloy (Cutaway shows uniform wall)

Diameter, 10"; weight, 45 lb.; material, Inconel X



Diameter, 29"; weight, 1000 lb.; material, Astroloy

Length, 18"; weight, 10 lb.; material, ironbase, high temperature alloy

Length, 22"; weight, 45 lb.; material, high-strength, nickel-base alloy

WYMAN-GORDON

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For more information write in No. 706

GT EDITORIALLY SPEAKING

Sales and Service

Until a product is sold and money changes hands, nothing of importance has happened.

Taking it from the beginning, you start with an invention . . . an idea, say for a gas turbine. Then comes the design stage and development starts. Prototypes are built and a program of testing starts, Finally you have a product . . . then comes the "long pause". You're facing tooling and production. Also, your final design must be adjusted to suit tooling capability and production efficiency. All this is time-consuming and costly and even when you start turning out units, where are you? . . . unless of course, you've built with a specific market or markets in mind, have planned a marketing program and have provided for service. Introducing a new form of power is a tough enough job at best. Without a definite merchandising and service program, you have two strikes against you. Another thing to consider is HOW the product is to be sold. There's a lot of difference in the method of selling a 100-hp turbine and a 10,000-hp unit. Let's look at the pattern in the piston engine field, a major competitor. Larger engines are usually sold through company branches by company-employed sales engineers. The smaller units, being practically a shelf-type production item, are normally sold through a system of distributors and dealers.

Next comes the matter of service. It's simply this: Service is not what you think it is but what the user considers to be service and has come to expect! Today's cost of downtime is prohibitive and users will not put up with much of it. Tolerable limits are determined by the currently existing situation in each field of application. So it would be well for gas turbine manufacturers to learn the merchandising and service patterns for prime movers in the fields that they want to penetrate.

It may not be one company that controls a gas turbine from its invention to its final application. One company may build and test the prototypes, another handle production and a third, the sales and service. Whatever the arrangement, these steps must be carefully worked out and coordinated. Such careful planning is necessary for the future of the gas turbine industry.

And to repeat, until a product is sold and money changes hands, nothing of importance has happened.

R. Tom Sawyer

From an original painting for CECO by R. T. Handville

Contributing to the superb performance . . . of each Ryan Q-2C Firebee is a Continental J-69 turbojet equipped with single-package *engine control and fuel pump* engineered and precision-produced by Chandler Evans.

Products, too, are "known by the company they keep", and CECO is proud to be airborne with an array of important missiles as well as with many of the latest and finest military and commercial aircraft.

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Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Department 30.

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GT HOT LINE

APS REPORTS ON YEAR OF PACKAGED-POWER BY THE HORSEPOWER HOUR . . .

Arizona Public Service Co. outlined their progress in selling engine powered "systems" to compete with other forms of energy. In their area, they're their own best competitor, since they also supply electrical power. Idea is to make a "package" of internal combustion power available to users at favorable costs without requiring them to make a capital investment. APS now has 85 engines in the field, selling "horsepower-hours" at a 10% cost advantage over their electrical power rate. They outlined their program at the National Engine Use Council meeting in Chicago. NEUC is an association of engine, accessory and component manufacturers (and other interested parties) who represent the industry as a whole, with the aim of increasing the use of all kinds of internal combustion engines.

ANOTHER IN THE PICTURE . . .

Volkswagen is studying possibilities of automotive gas turbine.

ALLISON T63 CHOSEN FOR LOH . . .

The Army has chosen Bell Helicopter and Hiller Aircraft to design competitive light observation helicopters. Both have selected the Allison 250-hp T63 gas turbine . . . Contract will be started through a development cycle. When one design is selected development will be completed and production started. Army is expected to purchase over 2000 aircraft over a 5-yr period . . . This will be first real production schedule for a small gas turbine.

TELEGRAM FROM CANADA . . .

"Canadian Pratt & Whitney Aircraft's flying testbed for its 500-hp free turbine PT6 engine made its first flight this week at Toronto. The engine was operated at powers up to normal rated during this first flight and the aircraft attained speeds of over 200-mph @ 10,-000-ft. The Beech 18 converted by Dehaviland Aircraft passed its flight alliance test and was turned over to Canadian P & W for the engine test program."

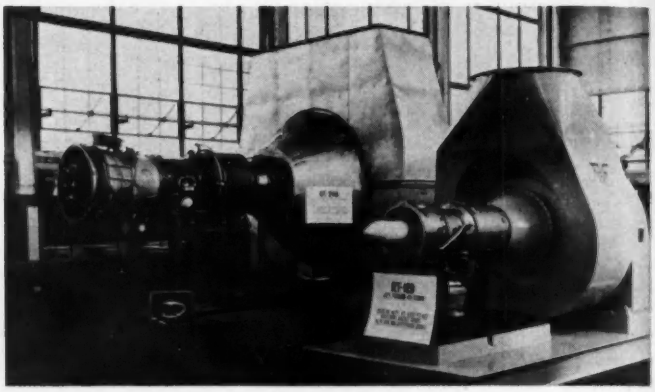
ENGLISH ELECTRIC LOCOMOTIVE ON THE RAILS . . .

2700-hp experimental gas turbine locomotive looks like a steamer with a wheel arrangement of 4-6-0 plus a 6-wheel tender. This is the first modern gas turbine locomotive with mechanical drive and heat exchanger (which means fuel economy).

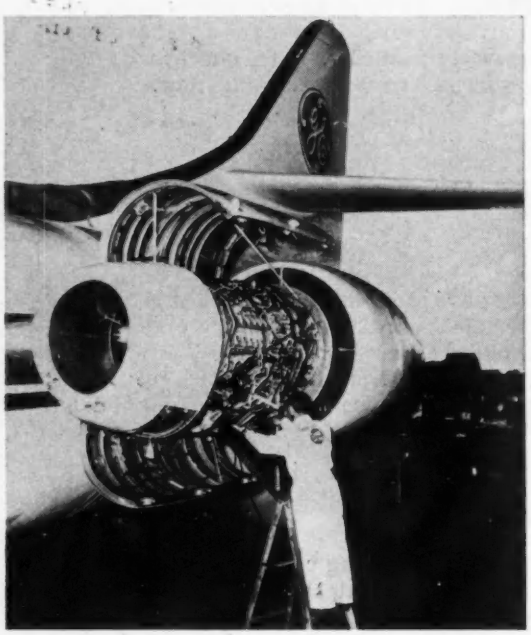
GE'S NEW MARINE AND INDUSTRIAL OPERATION . . .

General Electric has announced formation of a marine and industrial operation at its Flight Propulsion Division headquarters in Evendale, Ohio . . . New operation will pull together production of aircraft gas turbine engines that have been modified for marine and industrial use so these units will complement GE's other M & I gas turbine lines.

GT INDUSTRY NEWS



C-B "Roundup"
Cooper-Bessemer's RT-248 (10,500-hp) and RT-129 (2500-hp) gas turbines were caught by the editor's camera at C-B's "Power and Compression Roundup", where the company showed their facilities to key people from all over the country. Smaller unit, the RT-129, is expected to be available by early next year; larger unit is in operation at Clementsville.



"Short-Cowl" Nacelle
General Electric's CJ-805-23C engine is housed in new type "short cowl" nacelle, so-called because of separate inlets for basic engine and aft fan. Capable of 16,000 pounds take-off thrust, it will power Caravelle VII's, now in production in France.

Latest Sub Hunter
U.S. Navy's twin-turbine Sikorsky HSS-2, world's most advanced helicopter weapons system, hovers near destroyer during recent carrier suitability trials. USS Lake Champlain is in background. HSS-2 is scheduled to go into fleet service later this year, as submarine hunter-killer.

Japanese Firm Under Westinghouse License

Mitsubishi Heavy Industries, Reorganized, Limited, of Kobe, Japan, will begin manufacturing gas turbines this year under a license and technical assistance agreement announced by the Westinghouse Electric International Company. Under the agreement, Westinghouse will provide Mitsubishi with designs and engineering information and with material and process specifications for the manufacture of nonaviation open-cycle gas turbines, according to D. E. Akins, vice president of Westinghouse International.

AC Turbine Controls

Work in the turbine engine control-field has been started by AC Spark Plug Division in Flint. A group of engineers has been transferred to Flint from AC's Milwaukee plants to supervise design and development of the control devices, and the transfer is still under way. These engineers have been designing and building turbine engine control equipment since shortly after World War II. Products will include turbine engine fuels controls, speed monitors and speed switches.

Turbines To Give Army Tug Firefighting Power

Boeing gas turbines will provide pumping power for a dual purpose 100-ft. ocean-going tug-fireboat being converted for use by the U. S. Army Transportation Corps at Wilmington, N. C.

The Boeing Industrial Products Division has received an Army contract to supply two gas turbine-driven pumping units each rated at 2,000-gpm at 150-psi. Each pump will be driven by a Boeing 502-10MA gas turbine engine rated at 270-shp. The pumps are of the close-coupled single-stage centrifugal type, with 8-in. suction and 8-in. discharge.

Boeing turbine power was selected for this application because of the engine's compact size, starting reliability, ease of installation, and competitive cost. The turbine power plants do not deteriorate from infrequent use, which is another important factor in a fireboat application. The Boeing pumping package will include turbine, pump, sub-base enclosure, self-contained lubrication oil system and automatic pump pressure controls. The automatic controls will enable the unit to pump at any preselected pressure up to 250-psi without manual adjustment, regardless of the number of fire-fighting hoses or monitors on the line.

The new turbine pumping installation is expected to be completed by mid-summer 1961. The turbines will be built to standards of the American Bureau of Shipping.

Gas Turbine Makes Armament Possible

A universal armament kit could give the helicopter an important new role in the modern mobile army, Henry G. Benis, speaking before a meeting of the Institute of the Aerospace Sciences, pointed out. The new kit will offer protection for the helicopter, long vulnerable to enemy attack, and for the first time make it an aggressive fighting unit.

Delavan

Fuel Injectors

TOUGHER THAN TOUGH JOBS

■ Delavan specialists have broad experience in developing gas turbine fuel injectors that assure a high degree of reliability for long periods of time; that function consistently well under the most rugged conditions.

■ If you have a heavy-duty fuel injection problem consult us. Delavan engineers will develop a fuel injector that's tougher than the toughest job, hardier than the heaviest work. A Delavan injector may well reduce costs, save you valuable time or improve the performance of your equipment.

■ Delavan can bring a fund of developmental experience and manufacturing know-how that is unparalleled in the industry. Delavan is the world's largest manufacturer devoted to the design and manufacture of fuel injectors and spray nozzles.

■ *If an exacting fuel injector for gas turbines is needed . . . so is Delavan. For information write:*

DELAVAN Manufacturing Company

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For more information write in No. 708

INDUSTRY NEWS . . .

Sikorsky in San Francisco

The first of two Sikorsky S-62 helicopters to be used in the inauguration of passenger service in the San Francisco Bay area has been accepted by San Francisco & Oakland Helicopter Airlines. Delivery of the turbine-powered S-62 was taken by Bruce F. DeHaas, vice president, operations, and the aircraft is being flown to California by a San Francisco flight crew. The boat-hulled S-62 is powered by a single General Electric CT-58 gas turbine engine.

Bristol Siddeley Lift/Thrust Engine

Bristol Siddeley announce that the name "Pegasus" has been chosen for the BS 53 lift/thrust engine, which has already flown successfully in the Hawker 1127 VTOL/STOL strike aircraft. This name is particularly apt when it is recalled that the Pegasus of mythology was a winged horse with "vertical take-off capability".

English Electric Forms U. S. Company

The English Electric Corporation has been incorporated in the State of Delaware as a wholly-owned subsidiary of The English Electric Company Limited, of London, England. The new Corporation consolidates the U. S. activities of the English Electric Export and Trading Company, Marconi's Wireless Telegraph Company, Marconi Instruments and the English Electric Valve Company.

President of the Corporation is Mr. E. S. Dean, who has been English Electric's Group representative in the U. S. since 1949. Executive vice-president is Mr. Alan Barraclough, who has headed the English Electric Export and Trading Company in the U. S. since 1952. Commenting on the forming of the Corporation, Mr. Dean said: "The English Electric Group is no newcomer to this country. Our ties with the U. S. date back to 1899 when Guglielmo Marconi arrived in New York and founded the American Marconi Company, which later became R.C.A.

GT CONTRACTS PROCUREMENTS

Some major gas turbine procurements initiated and contracts awarded during recent months by various agencies of the U. S. Government are listed. This material is from the U. S. Department of Commerce publication "Synopsis of U. S. Government Proposed Procurement, Sales and Contract Awards."

• HQS, 2709th AF Vehicle Control Group, Memphis, Tenn. "Replacement Spare Parts applicable GTP 7C-9, 85-65, 85-52 and 75600 gas turbine compressors, various quantities. (Contract AF 40(604)-11050 to RFP 40-604-61-64 and subsequent negotiations thereto)"—$126,292—AiResearch Mfg. Co., Phoenix, Ariz.

• HQS, 1709th AF Vehicle Control Group USAF, Memphis, Tenn. "Governor Assembly over speed Mod T41M-6 Aircraft Gas Turbine Generator, FSN 2910-340-7208, 200 each. (Contract AF40-(604)-10962 to RFP 40-604-61-77 and subsequent negotiations thereto)"—$45,568—Woodward Governor Co., Rockford, Ill.

• HQS, Oklahoma City Air Material Area, USAF, Tinker AFB, Okla. "Overhaul, or modification, minor repair, test, packaging and preservation of J-47 Engine Nozzle Assy-Fuel. (RFP OC-1-03D-51 & 63)"—Job—$106,002—Aero Precision Industries, Inc., Oklahoma City, Okla.

• AMC Aeronautical Systems Center, Wright Patterson AFB, Ohio. J-85-GE-7 Turbojet Aircraft Engines, Aerno 35-6097. (Usage: ATC Spares) Supplemental Agreement No. 10, dtd 7 Nov 1960, to Contract AF 33(600)41577—5 ea—$320,000—General Electric Co., Small Aircraft Engine Dept., West Lynn, Mass.

• HQS, Warner Robins Air Material Area, USAF, Robins AFB, Ga. Bearings applicable to J71A9 Engine used on B/RB66 Aircraft (RFP61-2359)—$29,600—Hyatt Bearing Co., GMC, Harrison, N. J.

• HQS, Warner Robins Air Material Area, USAF, Robins AFB, Ga. Bearings applicable to Auto Pilot and T56 Engine (RFP 61-2359)—$40,180—The Fafnir Bearing Co., New Britain, Conn.

• HQS, Mobile Air Material Area, USAF, Brookley AFB, Ala. Overhaul and repair of gas turbines, AF 01(601)-33682,-56 ea—$332,190—Solar Aircraft Co., San Diego, Calif.

• HQS, Aeronautical Systems Div. (LMPMGC), Wright-Patterson AFB, Ohio. T-50-BO-4 Engines, Special Support Equipment and Spare Parts, Metal Engine Shipping Containers and Data. Letter Contract AF33 (600)42855, 17 Mar. 61—$290,000—Boeing Airplane Co., Industrial Products Div., Seattle, Wash.

• HQS, Aeronautical Systems Div., (LMPMGC), Wright-Patterson AFB, Ohio. T58-GE-8 Gearbox Assemblies, iaw/Contractor's Main Reduction Gear Assembly Spec. Nr. E-1051, 1 Sept. 60. (For support of T58-GE-8 Engine/HU2K-1 Navy Aircraft). Supplemental Agreement No. 4, 1 Mar. 61, to Contract AF33(600)-42313, 75 ea—$672,599—General Electric Co., West Lynn, Mass.

• HQS, Aeronautical Systems Div., (LMPMGC), Wright-Patterson AFB, Ohio. T56-A-7 Engines and Data. (For C-130E Aircraft) Supplemental Agreement No. 15, 16 Mar. 61, to Contract AF 33(600)-41738, 76 ea—$6,764,000—Allison Div., GMC, Indianapolis, Ind.

• HQS, Aeronautical Systems Division, (LMPMGC), Wright-Patterson AFB, Ohio. Maintenance, Overhaul and Support of twelve (12) T53-L-9 Acft Engines used in YHU-1D Aircraft Test Program. Contract AF 33(600)-42488, 16 Feb. 61—$430,376—Lycoming Div., AVCO, Stratford, Conn.

• HQS, Warner Robins Air Material Area, USAF, Robins AFB, Ga. Bearings applicable to J47 Engine (RFP-61-2587)—$219,750—Marlin-Rockwell Corp., Jamestown, N. Y.

• Dept. Navy, Bu. Naval Weapons, Washington 25, D. C. Thirty-three Model J60-P-3 Turbojet Engines. NOw 61-0448-f—$2,066,196—Pratt & Whitney Aircraft Div., East Hartford, Conn.

• Dept. Navy, Bu. Naval Weapons, Washington 25, D. C. Thirty-six Model JT12-A-6 Engines, NOw 61-0448-f—$2,271,384—Pratt & Whitney Aircraft Div. East Hartford, Conn.

• Aviation Supply Office, Phila., Pa. Jetcal Testers: Used to check jet aircraft engines. N383-68885A, 7 Mar 61, (383/262202/61)—Various—$39,639—Howell Instruments Inc., Fort Worth, Tex.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. J69-T-29 Engines, iaw/Contractor's Spec 2157C, 18 Oct 60. Contract AF 33(600)-42426, 18 Jan 1961, 213 ea.—$3,298,305—Continental Aviation and Engineering Corp., Toledo, Ohio.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. T55-L-5 Shaft-Turbine Aircraft Engines and Pre-production efforts therefore. (Installations and Spares for Army

HC-1b Aircraft FY-61) Contract AF 33(600)42267, 9 Dec 60—$9,505,889—Lycoming Div., AVCO, Stratford, Conn.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. Power Units, Gas Turbine Engine Type A/A 32-3, iaw/Contractor's Specification SC-5285, Revision "B" Contractor's Model GTC 85-71 Drawing No. SC 376730, FSN 2835-684-8097, Aerno 42-2352, (Installation and Spares for C-130E Aircraft) Spart Parts, Ground Support Equipment and related data. Contract AF 33(600)-42650, 6 Jan 61, 84 each—$915,180—The Garrett Corp., AiResearch Manufacturing Co., Phoenix, Ariz.

• HQS, Oklahoma City Air Material Area, USAF, Tinker AFB, Okla. 1660-627-9853, Turbine Assembly, 43 ea. AF 34(600)-8847, 2 Feb 61, (RFP OC-1-1660-1254)—$52,073—Hamilton Standard, Windsor Locks, Conn.

• HQS, San Antonio Air Material Area, USAF, Kelly AFB, Texas. Spare parts applicable to fuel controls in support of T34 engines, C133 Aircraft. AF 41(608)-12821 (PR: SA-1-2915-S15688 and SA-1-2915-E15655 L/P), 100 to 855 ea—$30,883—Holley Carburetor Co., Warren, Mich.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. Starter, Engine, Gas Turbine, Type STU-12/A34, iaw/Contractor's Specification SC-5063-R, Revision 10, 10 June 60, Contractor's Model ATSC100-1-4, P/N 350950. Aerno 42-8754, (Installations for F-105D Aircraft) Spare Parts, Ground Support Equipment and Data. Contract AF 33(600)42111, 241 ea—$1,016,391—The Garrett Corp., AiResearch Manufacturing Co., Phoenix, Ariz.

• HQS, Warner Robins Air Material Area, USAF, Robins AFB, Ga. Attn: WRPE. Bearings applicable to J-65 Engines (RFP-61-2353)—$839,213—SKF Industries, Inc., Phila., Pa.

• HQS, 2709th AF Vehicle Control Group, USAF, Memphis, Tenn. Probe Applicable MA-1 Compressor, FSN 2910-621-5004, 600 ea, and Probe applicable MA-1A Power Unit Gas Turbine, FSN 2910-624-7884, 500 ea, Contract AF 40(604)-11221 to RFP 40-604-61-127 and subsequent negotiations thereto—$151,800—Consolidated Controls Corp., Bethel, Conn.

• HQS, San Antonio Air Material Area, USAF, Kelly AFB, Texas. Spare parts applicable to T53-L-1B engines in support of H-43B Helicopter, AF 41 (608)-13334, 3 Mar. 61, (SA-1-2840E15507), 1 to 41 each—$174,842—Lycoming Div., AVCO, Stratford, Conn.

• HQS, Oklahoma City Air Material Area, USAF, Tinker AFB, Okla. Overhaul, repair and/or modification of Turbine Buckets AF 34(601)-8806, 28 Feb 61, (RFP OC-1-11-61) —$152,258—Allison Div., GMC, Indianapolis, Ind.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. Starters, Engine, Gas Turbine, Type STU-12/A34, Contractor's Model ATSC 100-1-4 P/N 350950, Aerno 42-8754, and Maintenance Data. (Replenishment Spares for F-105 B/D Aircraft) Contract AF 33 (600)-42611, 26 Jan 61, 82 ea.—$332,264—The Garrett Corp., AiResearch Mfg. Co., Phoenix, Ariz.

• HQS, Mobile Air Material Area, USAF Brookley AFB, Ala. Turbo-Starter with G. E. Electrical System Model 2CM214B1E, Air Compressor, Boeing Model 502-11B, IAW Boeing Spec D4-1030, 60KVA, alternator mounted in panel truck, AF 01(601)33630—4 ea—$101,960—Boeing Airplane Co., Seattle, Wash.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. Gas Turbine Compressors, Model GTC-85-56, iaw/Contractor's Model Specification SC-5259B, 8 Aug. 60, FSN VH 2835-724-0088 (Contractor's P/N 378374-1) Spare Parts and Revisions to Engineering Data. Supplemental Agreement No. 2, 10 Jan 61, to Contract AF 33(600) 41877, 16 ea.—$187,445—The Garrett Corp., AiResearch Mfg. Co., Phoenix, Ariz.

• HQS, San Antonio Air Material Area, USAF, Kelly AFB, Texas. Repair and/or overhaul of F106A/B Fuel System Components. AF 41(608)-12060 (pr: SA-0-2915-E10058), Definite Contract superseding Letter Contract—$328,483—General Dynamics Corp., Convair Div., San Diego, Calif.

• HQS, San Antonio Air Material Area, USAF, Kelly AFB, Texas. 2915-630-8513 Valve, applicable to Fuel System in support of B52 Series Aircraft. AF 41(608)-12914 (PR: OC-0-031-4221), 556 ea—$61,021—Crane Co., Hydro-Aire Co. Div., Burbank, Calif.

• HQS, Warner Robins Air Material Area, USAF, Robins AFB, Ga. Bearings applicable to T-56 Engine Gear Box (IFB 61-566)—$171,245—SKF Industries, Phila., Pa.

• Aviation Supply Office, Phila., Pa. Couplings: Used on GTC85 compressors. N383-67883A, 25 Nov 60, (JD-IFB-383-3-61), 506 ea—$52,624—On Mark Couplings Inc., Los Angeles, Calif.

• HQS, Mobile Air Material Area, USAF, Brookley AFB, Ala. Spare Parts for J79 aircraft engine, AF 01(601)35588 (01-601-61-2032-Q), 9072 ea—$27,787—Teleflex, Inc., North Wales, Pa.

• HQS, 2709th AF Vehicle Control Group, USAF, Memphis, Tenn. Switch Assembly applicable MA-1A Gas Turbine Engine, FSN 2920-621-5003, (Contract AF 40(604)-11148 re RFP 40-604-61-113 and subsequent negotiations thereto), 150 ea—$83,653—General Motors Corp., A. C. Spark Plug Div., GMC, Milwaukee, Wis.

GT "COMING UP" REMINDER

AUGUST 14-17 Society of Automotive Engineers, National West Coast Meeting, Sheraton Hotel, Portland, Ore.

AUGUST 19-24 Institute of the Aeronautical Sciences/Naval Aviation Meeting, Classified, San Diego, California.

AUGUST 28-SEPTEMBER 1 Institute of the Aeronautical Sciences, International Heat Transfer Conference, Boulder, Col.

AUGUST 28-30 American Society of Mechanical Engineers West Coast Conference of Applied Mechanics, University of Washington, Seattle, Washington.

SEPTEMBER 11-14 Society of Automotive Engineers, Heavy Duty Vehicle Meeting, including production forum and engineering display, Milwaukee Auditorium, Milwaukee, Wisconsin.

SEPTEMBER 11-15 Instrument Society of America Fall Instrument-Automation Conference and Exhibit and ISA's 16th Annual Meeting, The Biltmore Hotel, Los Angeles, Calif.

SEPTEMBER 24-27 American Society of Mechanical Engineers Petroleum Mechanical Engineering Conference, Muehlebach Hotel, Kansas City, Mo.

SEPTEMBER 24-27 ASME-AIEE National Power Conference, St. Francis Hotel, San Francisco, Calif.

OCTOBER 4-6 American Society of Mechanical Engineers Process Industries Conference, Shamrock Hilton Hotel, Houston, Texas.

OCTOBER 9-13 Society of Automotive Engineers, Aerospace Engineering and Manufacturing, including engineering display, The Ambassador, Los Angeles, California.

OCTOBER 17-19 American Society of Mechanical Engineers and American Society of Lubrication Engineers Lubrication Conference, Morrison Hotel, Chicago, Ill.

After the tremendous success of the
6th Annual Gas Turbine Conference and Products Show
Sponsored by the Gas Turbine Power Division of ASME
(see May-June Gas Turbine)

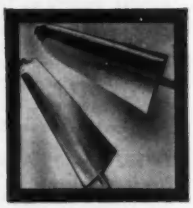
be sure to be at the **7th ANNUAL GAS TURBINE CONFERENCE AND PRODUCTS SHOW**
and Concurrent
2nd ANNUAL PROCESS INDUSTRIES CONFERENCE
Shamrock Hilton • Houston, Texas
• March 5-8, 1962
IN THE LAND OF THE USER

STALKER salutes

the new

TWA Convair SUPERJET

Stalker is proud to have had a part in developing and producing the light weight, precision-fabricated inlet guide vanes, a part of each of the four General Electric CJ 805-3 engines used for powering the TWA Convair Super Jet airliner.



Stalker product developments for the aviation industry include many precision-fabricated jet engine parts — rotors, stator vanes, nozzles, air-cooled turbine buckets — all incorporating Stalker's proven Ortho-braze methods. Stalker is equipped to handle both aerodynamic and structural testing of compressor components. Stalker quality control and inspection is USAF approved.

THE STALKER CORPORATION

Phone: Bay City — TWinbrook 3-7562

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Essexville, Michigan

For more information write in No. 709

INDUSTRY NEWS . . .

Contract to Garrett

The Navy has awarded a $5.2 million contract to The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona, for the purchase of gas turbine compressors and power units. Selection to manufacture the units was on the basis of a design competition. The mobile power packages are used for main engine starting, electrical servicing and air conditioning of aircraft.

Canadian Service Helicopter

A Sikorsky S-62 amphibious turbo-powered helicopter, with a 400-mi. flight range, equipped for carrying light package freight and for search-and-rescue operations, has been ordered by the Department of Transport, it was announced today by Hon. Leon Balcer, Minister of Transport. It is expected to be operational in late summer.

The helicopter will serve the whole British Columbia coast, under the joint direction of the District Marine Agents at Prince Rupert and Victoria, except when required by the Rescue Co-ordination Centre at Vancouver. Maintenance will be carried out at Department of Transport Air Service Hangar at Vancouver.

Bristol Siddeley in Moscow

Bristol Siddeley at the British Trade Fair in Moscow display showed a sectioned industrial Proteus gas turbine engine and also models of both the transportable and fixed site Proteus-powered 3 Megawatt generating sets, several of which are now in service and on order.

Check Lloyd's

Lloyd's Register of Shipping recently made additions and amendments to the society's rules and regulations for the construction and classification of steel ships. Some of these modifications concerned gas turbines. These include under Section H4: plans, materials, stability testing of rotors, design and construction, welded components, governors and other safety devices, emergency arrangements, astern power, hydraulic tests and trials. Details are contained in Lloyd's Notice No. 2182. Further information can be obtained by contacting Lloyd's Register of Shipping, 17 Battery Place, New York 4, N. Y.

Environmental Research

With the increasing importance of gas turbines in military strategy, determining the wearing effects of dust and dust concentrations in various parts of the world has become a matter of urgency. Southwest Research Institute's Environmental Research Section, headed by Robert Engelhard, is in the process of tracking down how much dust will be raised by military and civilian equipment operating under conditions of varying severity in various parts of the world. The second part of the job is to predict the amount of wear and damage the dust will do to equipment.

3-Pound Turbogenerator

A contract for the development of a miniature turbogenerator designed for one-shot missile applications has been awarded The Garrett Corporation's AiResearch Manufacturing Company of Los Angeles by the Picatinny Arsenal, Ordnance Corps, U.S. Army, Dover, N. J. The turbogenerator, powered by a solid propellant, will be capable of supplying 150-watts (AC and DC) for 100-seconds duration. The turbogenerator includes a gas generator, turbine, electrical generator, controls, regulators and rectifiers.

Turbines Controlling Laminar Flow

A contract in excess of $1,000,000 covering development and delivery of pumping systems for the Northrop Corporation laminar flow control test aircraft has been received by The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona.

Laminar flow control, originally known as low drag boundary layer control, is based on 11 years of Northrop research. In a U.S. Air Force-sponsored program totaling more than $20,000,000, Northrop is

redesigning two twin-engine USAF aircraft for flight demonstration of laminar flow control efficiency under all operating conditions.

The AiResearch system uses two bleed air turbine-driven compressors for each wing. Air from the upper wing surface and leading edge is first ducted into a low pressure, and then into a high pressure compressor along with air from the lower wing surface and trailing edge. Discharged aft, the boundary layer air and turbine exhaust provide additional aircraft thrust.

Solar Gas Line Pumper

Tennessee Gas Pipeline Company has ordered a new Solar gas turbine-driven centrifugal compressor for installation on its large natural gas pipeline system, it was announced today by Morris Sievert, manager of turbomachinery sales for Solar Aircraft Company. The compressor unit, driven by a Solar T-1000 engine, will be installed at Tennessee Gas Company's Leeville, La., compressor station. It will be used to boost the pressure and the flow of natural gas in the pipeline.

Solar's new line of direct coupled centrifugal gas compressors will operate from 75- to 1000-inlet cu. ft. per minute at up to 1500-psi, Sievert said. This range formerly was limited almost exclusively to reciprocating equipment. Solar's T-1000 gas turbine engine delivers 1100-hp. Weight of the engine and compressor unit will be approximately 5,000-lbs.

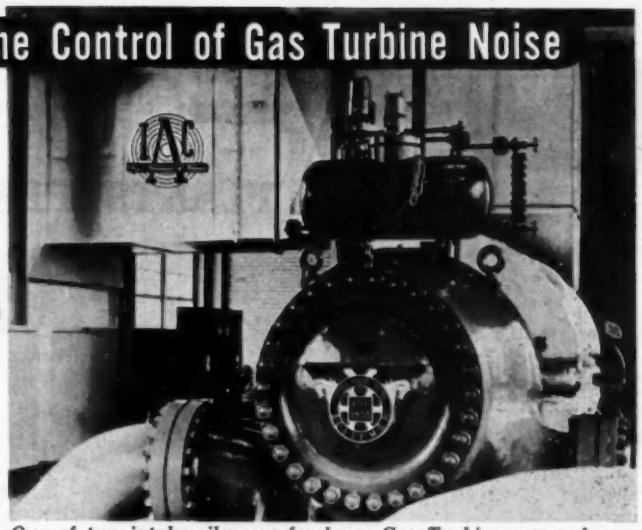
Turbines Tumble Flight Records

U. S. turbine-powered airliners last year soared to new performance heights, increasing their patronage more than 150% during the second full year of operation.

During 1959, U. S. scheduled carriers flew 7,715,000,000 revenue passenger miles in jets, both turbojet and turboprop. This was 21.2% of the total number of revenue passenger miles flown by all scheduled planes that year.

Last year, jets flew 19,510,000,000 revenue passenger miles, an increase of 153% from the previous year.

For the Control of Gas Turbine Noise



One of two intake silencers for large Gas Turbine powered compressor in a gas pipe line transmission facility.

IAC Intake and Exhaust Silencers have solved special noise problems in hundreds of installations. Our Engineering Department will gladly work with you in solving your noise problems.

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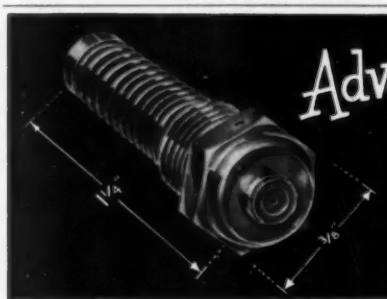
IAC Mufflers are available in five series for Low to High (up to and including Sonic-Flow) velocities. Ask for Bulletin #MUF-218.

For more information write in No. 710



Advanced Design!

"Variable area-Simplex" Fuel Injector for Gas Turbine Engines

An advanced concept in fuel injection has enabled combining low flow "Simplex" characteristics with the linear high flow range characteristics of the Variable area Poppet Injector.

This advancement achieves highly atomized fluid over the full flow range desired with a 100 to 1 flow range using a 6 to 1 pressure range. Low flows from 6 to 30 PPH are scheduled along a simplex curve and high flows from 30 to 1800 PPH are scheduled through the variable area poppet.

The photo illustrates the dual spray cones of highly atomized fuel when the transition from simplex to variable area linear flow occurs. Precision calibration of production nozzles eliminates the need of a flow divider and simplifies the plumbing system. Tolerances of ±3% at high flow and ±3% at simplex set point flow are readily available without selective grouping. The injector which weighs only ¼ ounce (⅜" Hex x 1¼" long) is constructed of stainless steel and incorporates an "Inconel X" spring.

EPCO

EPCO engineers stand ready to devote their extensive background in nozzle design and development to solve your exacting fuel injector requirements.

For more information, write or call

THE ENGINEERED PRODUCTS CO.
P.O. BOX 108, FLINT, MICHIGAN PHONE CEdar 9-8689

For more information write in No. 711

GT PEOPLE PLANTS PLACES

Lemmerman's Sales Mgr.

The appointment of **Carl W. Lemmerman** as Sales Manager of the Acoustics and Instruments Division, has been announced by Dr. B. K. Erdoss, President of **The Korfund Company, Inc.**, Westbury, L. I.

Lycoming and Piaggio Sign Agreement

An agreement covering the manufacture of Lycoming's T53 and T55 gas turbine engines by **Piaggio & Co.**, Genoa, Italy, has been signed by Avco Corporation's **Lycoming Division**, Stratford, Conn. This was announced by James R. Kerr, president of Avco and Armando Piaggio, managing director of the Italian firm.

Piaggio, which first began construction of aircraft in 1916, has for several years been producing Lycoming reciprocating engines under a license arrangement. In addition, the Italian company manufactures single and twin engine aircraft for commercial use as well as for the Italian and other military services. These aircraft are powered by Piaggio-built Lycoming engines.

Schulze and Sheller Waukesha Vice Presidents

F. C. Schulze has been advanced to the post of Vice President of Sales and **A. Poster Sheller** has been named Vice President of Manufacturing for the **Waukesha Motor Company.** The announcement was made by Mr. C. E. Nelson, President.

Mr. Schulze had held the position of General Sales Manager since 1949. As Vice President of Sales, Mr. Schulze will direct and coordinate the Motor Company's sales efforts throughout the country and in foreign markets.

In his new position, Mr. Sheller will supervise and coordinate activities of the departments within the organization directly concerned with or closely related to the manufacturing process. These include purchasing, tool design, plant engineering, personnel, inspection, production, manufacturing, rate and time study, and the Climax plant at Clinton, Iowa.

Waukesha now include in their line of engines a 400/600-hp gas turbine industrial unit developed in cooperation with the Williams Research Corporation.

World Record Holders

Cdr. Patrick L. Sullivan (left), pilot, and **Lt. Beverly W. Witherspoon,** co-pilot, are shown in front of the U. S. Navy/Sikorsky HSS-2 helicopter in which they set a world helicopter speed record of 192.9 miles an hour May 17, 1961. The HSS-2 is powered by two General Electric T-58-8 1250-hp each gas turbines, shown in the upper left of photo (picture below).

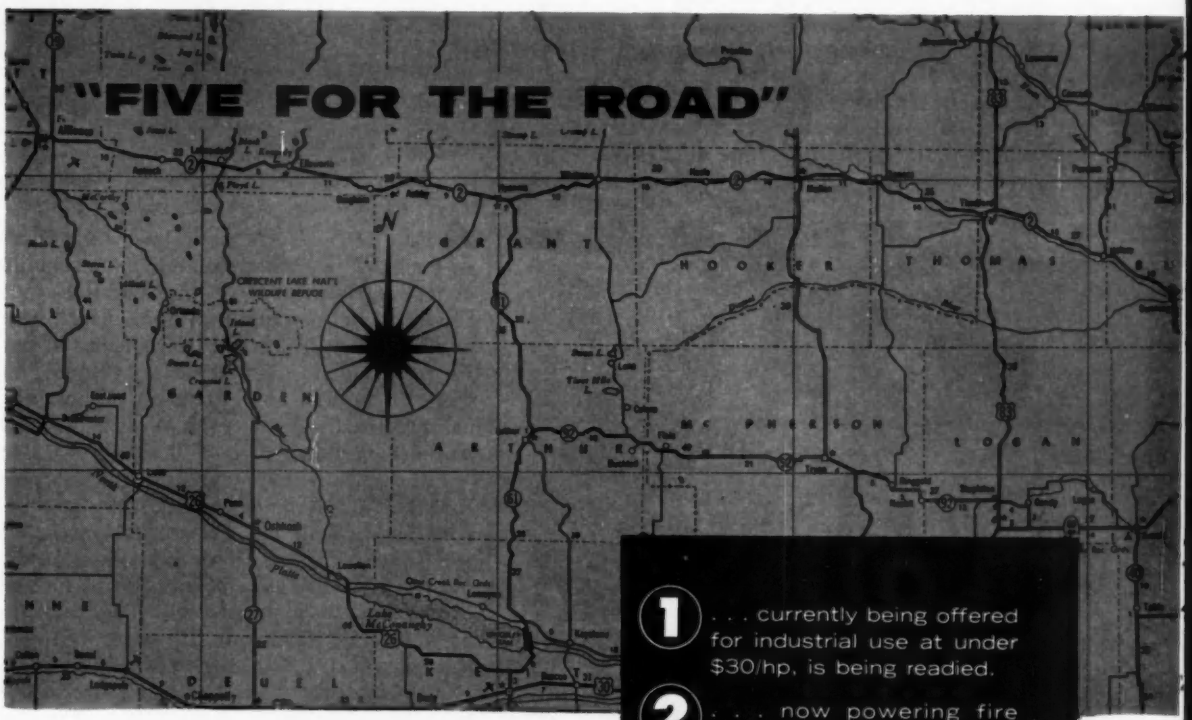
Solar Manager

Leon H. Fish has been appointed manager of **Solar Aircraft Company's** Dayton, Ohio, branch office, Solar President Herbert Kunzel announced. Fish will be in charge of Solar military relations activities at Air Force installations in the Dayton area, including Wright-Patterson Air Force Base, and Strategic Air Command headquarters in Omaha, Neb.

Award to Alford

The Royal Aeronautical Society has awarded the Herbert Agroyd Stuart Memorial Prize to **J. S. Alford,** Designing Engineer at **General Electric's** Flight Propulsion Division. Mr. Alford won this honor for his paper, "Power Plants for Supersonic Transports" which he delivered as the Second Halford Memorial Lecture before the Hatfield Branch of the Society last May.

Cdr. Patrick L. Sullivan and Lt. Beverly W. Witherspoon



1. . . . currently being offered for industrial use at under $30/hp, is being readied.
2. . . . now powering fire trucks on the west coast.
3. . . . being fitted into a Land Speed Record Car, a "Streamliner" designed for speeds from 500-600-mph.
4. . . . aircraft application is a transitional stage between industrial use and automotive application.
5. . . . well along in final stages of development for the American mass market.

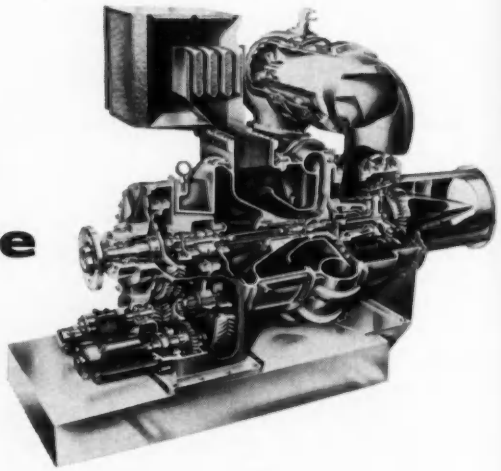
special automotive section

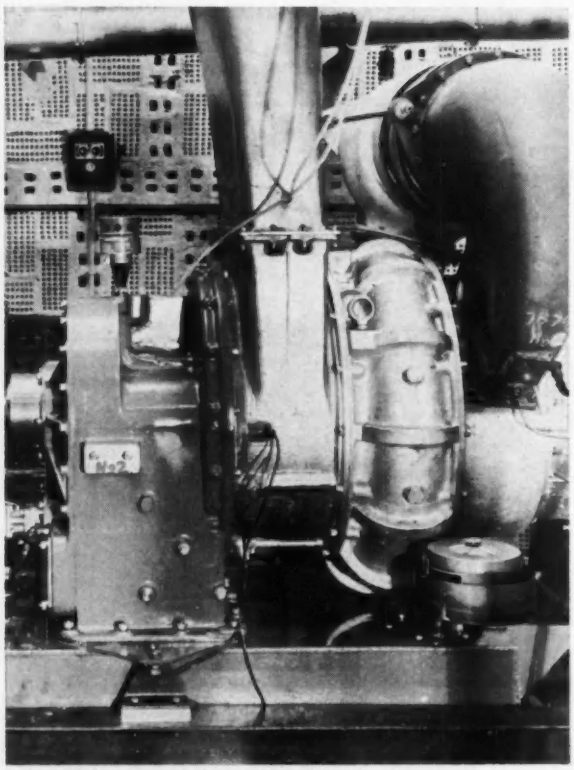
1

Automotive Report:

Austin's 250-hp Industrial Turbine

. . . rugged, compact, versatile
. . . priced under $30/hp



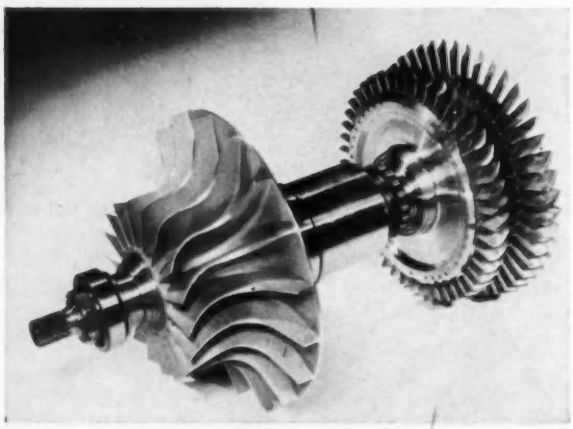


Left to right: power shaft, gearbox, air intake, compressor, combustor above compressor with inlet pipe into turbine next to compressor.

Austin of England's gas turbine is specifically designed for industrial application and is outstanding because of its simple, rugged construction. It is the result of 12-years secret development during which time the only published facts concerned a turbine-driven car. This car served as mobile test bed that contributed to development of the unit now placed on the market. Development was headed by Dr. John Weaving, Chief of B.M.C. Turbine Research.

British Motor Corporation engineers are confident that the Austin 250 gas turbine will withstand years of hard service with very low maintenance costs. This is what it was designed to do. In addition, it will burn almost any suitable type of inexpensive fuel, developing 250-hp from a weight of 900-lbs and measurements of 37-in. (l) by 35-in. (w) by 51-in. (h). In its basic form, it will cost in the region of only $7000.

Although the unit is specifically designed for industrial application, it is at the same time a major step



Single shaft of Austin 250-hp turbine with centrifugal compressor and two-stage axial-flow turbine.

toward eventual production of a vehicular turbine. It is one of the links in the corporation's chain of development of this interesting type of prime mover that is anticipated to culminate in a 250-hp gas turbine for high-speed heavy-commercial vehicles and other forms of land transport.

Austin's 250 Gas Turbine is a single-shaft machine with the turbine rotor driving the centrifugal compressor at a speed of 29,000-rpm. Pressure ratio is 3.5:1. Power is taken from the rotor assembly through a two-step lay-shaft reduction gear. Double-helical gears are used for long life. The output speed is reduced to 1800-rpm, or any other required speed.

Because of its simplicity, small bulk and weight, the Austin 250 lends itself admirably to applications where space-saving or lightness is important. A high overall thermal utilization may be obtained in applications where use can be made of the exhaust heat for process work. Its ability to use inexpensive fuels, such as methane and other by-product fuels, also gives it many applicational advantages.

Initially, the Austin 250 Gas Turbine will be available in three forms, all without heat exchanger:

(1) Coupled to a 160-kw alternator for electrical power generation.

(2) Coupled to a centrifugal water pump.

(3) As a separate power unit for driving almost any kind of industrial machinery.

This turbine, however, has been developed in two forms: As a heat exchanger unit for continuous development of power, and without heat exchanger for emergency and other special purposes. It is being marketed initially without heat exchanger.

During the past twelve years of development, Austin's Gas Turbine Research Department has investigated a large number of promising ideas, both on paper and on highly-instrumented test beds. In addition to two quite different complete turbine units (both with heat exchangers,) they have investigated single—and 2 stage centrifugal compressors; one, two, and three-stage turbines; inward flow radial turbines; cross-flow and contra-flow heat exhangers; vaporising combustion chambers; and atomiser combustion chambers. It is from this wealth of experiene that Austin engineers were able to produce this rugged, compact and versatile industrial gas turbine—and with a very attractive price tag!

Turbine-Powered Trucks take to the road

2

Automotive Report:

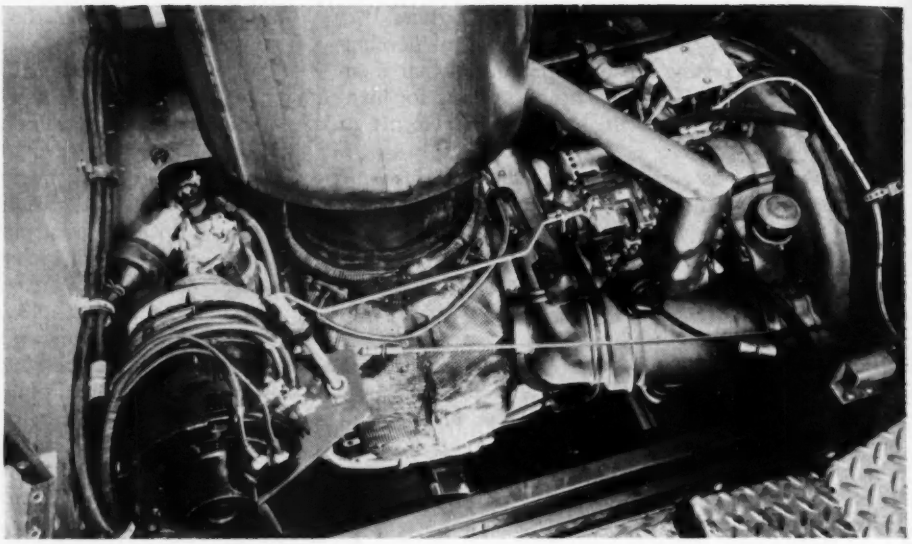
Chrome exhaust stack marks location of gas turbine in ladder truck of Seattle Fire Department. Turbine is one third the size, one tenth the weight conventional engine.

BY W. J. GRANBERG

Powered by an engine that weighs only 335 pounds but turns up 330 horsepower, the world's first gas turbine-powered production-line truck has taken to the road. It is the new $52,000 aerial ladder truck of the Seattle, Wash., Fire Department. Power source is a Model 502-10MA Boeing turbine.

After a series of road tests, the truck was accepted for regular service by the department on April 14. Shortly thereafter, another truck powered by a similar turbine was scheduled to go into service. This one is a pumper owned by the San Francisco Fire Department. Both trucks were built by American LaFrance at its plant in Elmira, N. Y., where the turbines, product of the Boeing Airplane Company's Industrial Products Division, were installed. These units are backed up by Boeing's 17 years worth of experience in the gas turbine business.

The turbine is one-tenth the weight of a reciprocating engine for a similar installation, and one-third the size. Its actual measurements are: length, 41.5-in.; width, 24-in.; height, 27-in. In addition to low weight and bulk,



330-hp Boeing gas turbine installation in fire truck. Gas-producer section is at right and power output section at left with exhaust stack in center. This 100-ft American La France aerial ladder truck went into regular service April 4th at the Seattle Fire Department.

. . . Turbine-powered trucks take to the road

serviceability is a big factor. The engine may be torn down, overhauled and reassembled in one day.

In pre-delivery performance tests, with no warm-up required, the ladder truck accelerated from a standing start to 25-mph in nine seconds, and from standing to 60-mph in 30 seconds. These are very creditable acceleration times for a truck. The turbine, driving through a 5-speed gear box, provides a high degree of flexibility to the truck under different loads at different speeds. A power take-off raises and maneuvers the truck's 100-foot aerial ladder.

Engine

The engine consists of two major sections: a gas-producer and the power-output section. The former contains a single-entry centrifugal compressor coupled to a single-stage axial-flow turbine, two cross-connected combustion chambers of the through-flow type, and an accessory-drive section. The power-output section incorporates a second axial-flow turbine, reduction gearing, and a flanged output shaft.

There is no mechanical coupling between the turbine rotors of the gas-producer and power-output sections. This arrangement permits the gas-producer speed and engine power to be controlled independently of the output shaft speed. Result is an engine with output speed variable from zero to 110% of rated rpm for either full- or part-throttle operation. Continuous operation at near stalled output shaft condition does not overheat the engine.

Principle of operation is simple. Air pulled in by the impeller is compressed, mixed with fuel, and burned to power the gas-producer turbine which maintains the compression-combustion cycle. The hot exhaust gases turn the free power turbine which is connected through reduction gearing to the output shaft. The standard reduction gear has a 8.9:1 ratio.

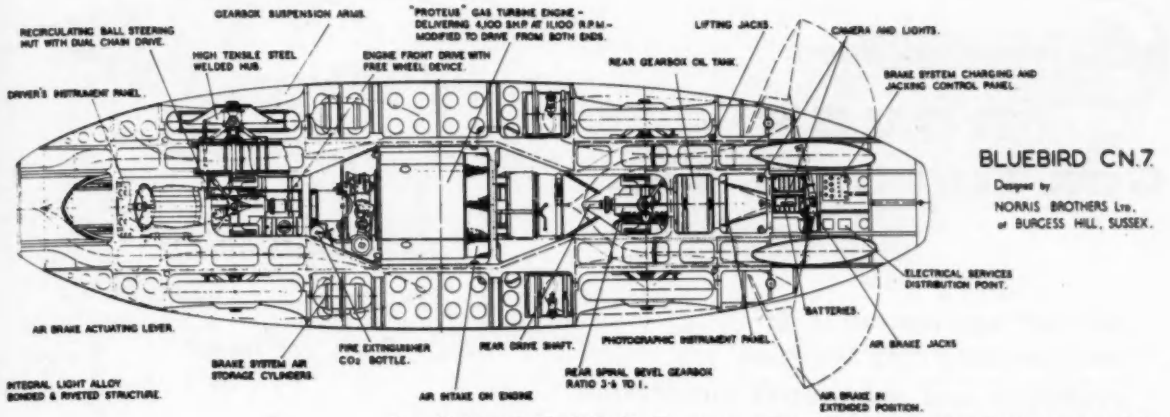
The engine is cooled by a positive flow of cooling air forced up the stack by the exhaust. This carries heat from the nozzle box and gas-producer accessory section. Under normal operating conditions the average skin temperature of the nozzle box is approximately 1300°F, and that of the exhaust ducts, 500°F. This ventilating air flow of 1000-cfm at sea level is required to prevent overheating. In order to obviate loss of power, hot air is prevented from entering the compressor inlet by a baffle behind the inlet bell or silencer.

The Seattle truck uses diesel fuel, although jet engine fuel or kerosene may be used without changes in the fuel system. Fuel is supplied under pressure to the burner nozzles by the engine-driven fuel pump and governor unit which provides speed control of the gas-producer. Fuel nozzle pressure normally will vary from approximately 30-psi at idle to 250-psi at maximum engine speed.

Lubricating oil (SAE 10) consumption is estimated at less than one quart in 15 hours of operation. The oil sump is part of the gas-producer section and has a capacity of six quarts. Two double element pumps, one on the first stage and one on the second, supply oil under pressure through a full-flow micronic filter to bearings and gears.

Oil is scavenged in the power-output section. Minimum oil pressure allowable at rated speed is 20-psi and normally will vary from 30 to 40-psi at rated speed to 10-psi at idle. During normal operation, temperature of oil to the engine ranges from 120°F to 180°F and should never exceed 220°F. An oil cooler is provided in the oil supply system.

The little gas turbine appeared a little incongruous in the long ladder-rig that has a gross weight of 32,000 pounds. Yet, it drove the fire rig up Seattle's steepest hill at 25 mph. More conventionally-powered equipment takes the same grade at a fast walk.


RECIRCULATING BALL STEERING NUT WITH DUAL CHAIN DRIVE.
GEARBOX SUSPENSION ARMS.
"PROTEUS" GAS TURBINE ENGINE - DELIVERING 4,100 SHP AT 11,000 R.P.M.- MODIFIED TO DRIVE FROM BOTH ENDS.
LIFTING JACKS.
CAMERA AND LIGHTS.
HIGH TENSILE STEEL WELDED HUB.
ENGINE FRONT DRIVE WITH FREE WHEEL DEVICE.
REAR GEARBOX OIL TANK.
BRAKE SYSTEM CHARGING AND JACKING CONTROL PANEL.
DRIVER'S INSTRUMENT PANEL.
BLUEBIRD CN.7
Designed by
NORRIS BROTHERS Ltd.
of BURGESS HILL, SUSSEX.
ELECTRICAL SERVICES DISTRIBUTION POINT.
BATTERIES.
AIR BRAKE ACTUATING LEVER.
FIRE EXTINGUISHER CO_2 BOTTLE.
REAR DRIVE SHAFT.
PHOTOGRAPHIC INSTRUMENT PANEL.
AIR BRAKE JACKS
BRAKE SYSTEM AIR STORAGE CYLINDERS.
REAR SPIRAL BEVEL GEARBOX RATIO 3·6 TO 1.
INTEGRAL LIGHT ALLOY BONDED & RIVETED STRUCTURE.
AIR INTAKE ON ENGINE
AIR BRAKE IN EXTENDED POSITION.

Donald Campbell's "Bluebird", powered by a Bristol Siddeley Proteus gas turbine.

Power for Campbell's "Bluebird" – 4100 hp!

Observations on development of car for land speed record bid from a personal letter to the Consulting Editor from Basil G. Markham of Bristol Siddeley Engines.

"This (car) has been quite an interesting little job for us and has involved testing the engine under some rather special conditions. It has required some drastic adjustments of our ideas which, as far as the Proteus is concerned, have always been focussed on producing an engine to last for several thousand hours with the minimum of maintenance and overhaul at about 2000 hours. The engine in the car will only have to run for about two minutes in each direction on the record breaking run.

"On our bench tests of the engine we found that the static torque developed at a given gas generator speed was a much higher percentage of the maximum horse power torque than we had anticipated.

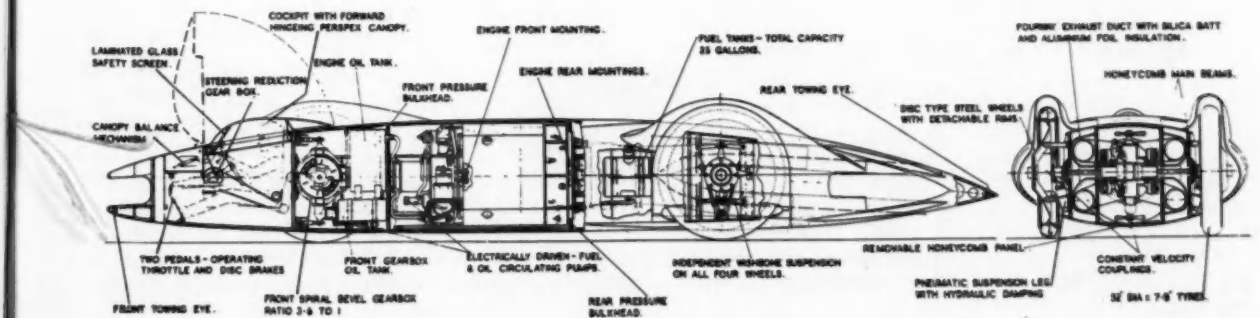
"I think it is fairly general experience that 2-shaft gas turbines of this type will give more than twice the full power torque when stalled. The Proteus, however, gives a ratio of over 3/1 at the highest gas generator speeds that we have run at stalled or nearly-stalled power turbine conditions. This high stalled torque is, however, associated with a sharp increase in turbine temperature. At a constant gas generator speed, the turbine temperature remains almost constant down to about half-power turbine speed but then starts to rise and this is the price that one apparently has to pay for getting this unexpectedly high stalled torque.

"Another interesting feature of the car installation is the low exhaust noise level. I think this is due to splitting the exhaust into four outlets, two above the car body and two below. This exhaust arrangement was not, of course, done purposely to make the car quieter but to allow us to take a drive from the rear of the engine to the back wheels, the driving shaft passing between the four exhaust outlets (The front wheels are driven by a shaft from the front of the turbine).

"We find Gas Turbine Magazine most interesting and I would like to take this opportunity of congratulating you on it."

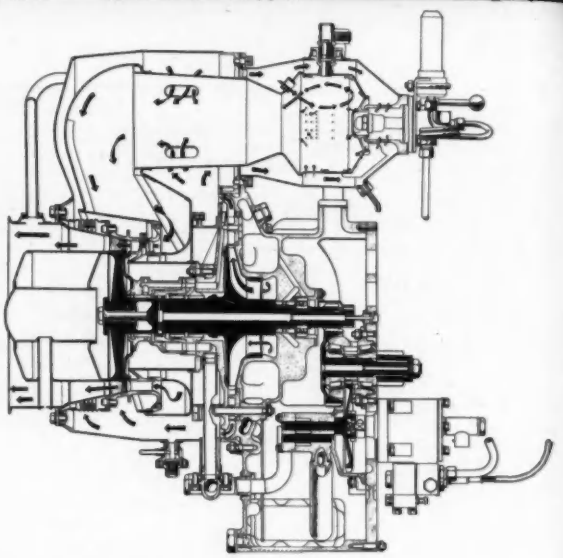
We wish to thank Mr. Markham for this unusually fine diagram of the Bluebird as well as the above.

Last year this car, the Bluebird, made some speed trials on the Utah Salt Flats and ended up in a crash due to a soft spot on the runway. The car has been rebuilt with improvements and speeds trials will again be made this year, possibly in Australia, at which time we hope this gas turbine-powered car will win all honors.


COCKPIT WITH FORWARD HINGEING PERSPEX CANOPY.
LAMINATED GLASS SAFETY SCREEN.
ENGINE OIL TANK.
ENGINE FRONT MOUNTING.
FUEL TANKS - TOTAL CAPACITY 25 GALLONS.
FOURWAY EXHAUST DUCT WITH SILICA BATT AND ALUMINIUM FOIL INSULATION.
STEERING REDUCTION GEAR BOX.
ENGINE REAR MOUNTINGS.
HONEYCOMB MAIN BEAMS.
FRONT PRESSURE BULKHEAD.
REAR TOWING EYE.
CANOPY BALANCE MECHANISM.
DISC TYPE STEEL WHEELS WITH DETACHABLE RIMS.
TWO PEDALS - OPERATING THROTTLE AND DISC BRAKES
FRONT GEARBOX OIL TANK.
ELECTRICALLY DRIVEN - FUEL & OIL CIRCULATING PUMPS.
INDEPENDENT WISHBONE SUSPENSION ON ALL FOUR WHEELS.
REMOVABLE HONEYCOMB PANEL.
CONSTANT VELOCITY COUPLINGS.
FRONT TOWING EYE.
FRONT SPIRAL BEVEL GEARBOX RATIO 3·6 TO 1
REAR PRESSURE BULKHEAD.
PNEUMATIC SUSPENSION LEG WITH HYDRAULIC DAMPING
52" DIA x 7·6" TYRES.

4 *Automotive Report:*

ROVER Gas Turbines, Ltd.



Aircraft application is an intermediate step between prototype and automotive application

Rover's connection with gas turbine engine development goes back to 1940. This was when the Rover Company was associated with Air-Commodore Sir Frank Whittle in the early days of the Whittle jet engine for aircraft. Then, Rover was building some of the first of these engines and was responsible for the design from which the famous Rolls Royce "Nene"' and "Derwent" engines were developed.

With the end of the war and the return of civil activities to the Solihull factory, it was felt that the pool of highly-specialized knowledge gained on gas turbine engine design and production during the war was too valuable to be allowed to remain stagnant. So, a team of twenty engineers, headed by Mr. Maurice Wilks, the present Managing Director who was then Rover's Chief Engineer, embarked on a development program for small gas turbine units. Eventual goal was to be a suitable unit for installation in an automobile.

On March 9th, 1950, at Silverstone race track, a demonstration took place which will without a doubt always be recognized as one of the most important turning points in the development of road transport. Before a large and distinguished audience, the world's first gas turbine-propelled car was put through its paces. It gave such a convincing demonstration that it created world-wide interest.

On June 25th and 26th, 1952, speed trials, officially observed by the Belgium Royal Automobile Club and subsequently recognized, were held on the Jabbeke motor road near Ostend, Belgium.

Times recorded over a measured mile and kilometer were: flying kilometer—151.965-mph; flying mile—151.196-mph; standing kilometer—132.596-kph, and standing mile—95.668-mph.

A statement issued by the Rover Company at the time of the trials stressed that they were there "to establish a stage in the development of the car and it should not be constructed as meaning that it (the car) was anywhere near its production stage."

In 1956 the latest prototype appeared as the T.3 and although still very much an experimental model, it took the Earls Court Motor Show by storm. This particular model is still the basis for further development necessary before any thought of large production can be considered.

Other Gas Turbine Work

While gas turbine progress in car application was receiving much attention, work was still progressing in industrial units. Rover generating and instructional sets, together with fire fighting units, were steadily being produced for many and varied applications. Rover water pump sets are currently operating with the British and Allied Armed Forces, while many generating sets are in use as standard equipment in the Royal Navy's new "Brave" class fast patrol boats and the "Ferocity," a new high-speed boat. Aircraft auxiliary power plants are already in production for the Vulcan and Armstrong Whitworth "660" aircraft. Many of these units are also widely used in the aviation field where the LS/60 engine is already well known.

Turbo-Prop Engines

To meet present and future needs of club and executive aircraft, Rover Gas Turbines Ltd., has initiated development of their single-shaft engines as turbo-propeller power plants. These are designated T.P./60 and T.P./90.

Design is based on the well-known industrial gas turbine engines of 60-hp and 90-hp output. These engines have amassed considerable world-wide background running in a variety of applications and are proving reliable and easy to maintain under widely-varying climatic conditions.

Vibration-free operation, low maintenance requirements, accessibility of units and long life will enhance the operation of light aircraft. Safety devices to ensure correct operation of the engines are incorporated, all of which are designed "fail safe."

Fuel can be any light liquid distillate, but the T.P./60 and T.P./90 power plants operate on kerosene or diesel fuel. This provides a safety factor to be coupled with economic operation.

We now find a new intermediate step between the prototype design and the automotive turbine—the aircraft application. Such an aircraft unit can reasonably be expected to work well. It has already proven itself in industry . . . and we're getting closer to the automotive turbine!

Chrysler's Automotive Turbine . . .

5

Automotive Report: **uses a variable turbine nozzle for a broad high-performance range . . . a regenerator for fuel economy. Carries all accessory drives, too.**

Chrysler's latest "break-through," announced and demonstrated at the recent Gas Turbine Show, was use of a variable-stage nozzle to the power turbine. It is automatically operated to give high efficiency and performance in both acceleration or braking, in fact, over the entire operating range of the car.

Over the years Chrysler has built at least seven cars to demonstrate development of their gas turbine. In all cases a regenerator was used. In all cases the incentive has been to produce a better economically-operating car.

And what is the result today? Chrysler has a remarkable sports car (body built by Ghia of Italy) built purely for show. But in this car is a power plant that can be used for many other applications. In a car (or truck) this gas turbine now handles:

(1.) Vehicle drive
(2.) Generator drive
(3.) Accessory drive
(4.) Air-conditioning unit drive
(5.) A complete heating system.

Odd as it may seem, this same power plant in an industrial application would have a much easier job. An industrial power plant seldom has more than one job to do. Yet when a turbine is put in a car, the power plant has at least five jobs to do—all at one time—and economically too.

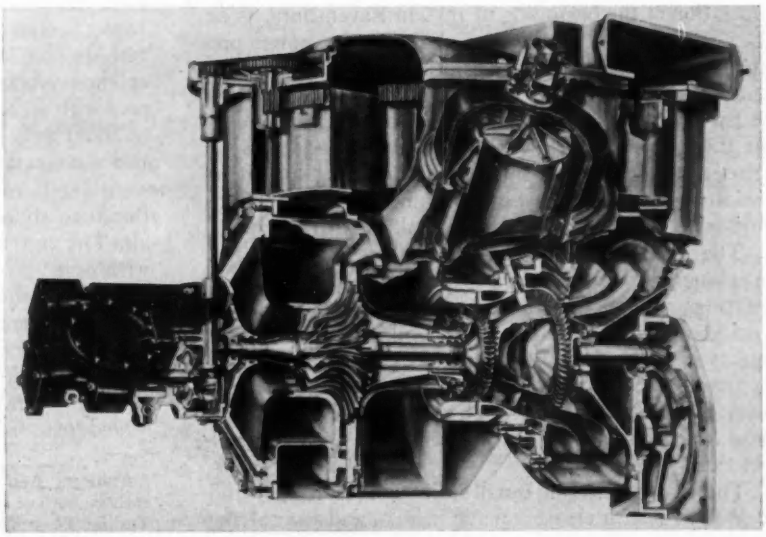
Economy does not only mean a low fuel consumption, say, 0.51 lb/hp hr at full load . . . or that there is practically no lubrication expense. This means definitely better economy in terms of "overall cost of ownership" than the power plant in present cars giving similar performance. Chrysler thinks that they have the means to do this.

If you are interested in one of these Chrysler power plants, you may have to wait for final developments. In the Chrysler brochure the following statement is made:

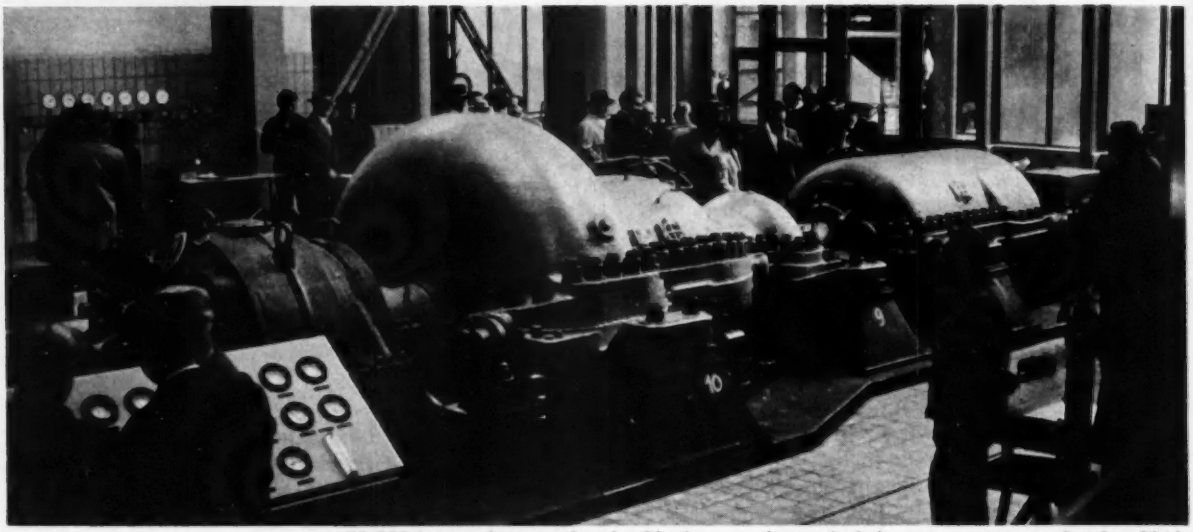
"As the CR2A gas turbine has reached a stage of development where it may become feasible to offer it for sale to selected buyers, Chrysler Corporation is considering making a limited number of these power plants available on a negotiated basis to potential users for study and evaluation in experimental applications. Any inquiry in this respect should be directed to Mr. G. J. Huebner, Jr., Executive Engineer-Research, Chrysler Corporation, Engineering Division."

SUMMARY OF CR2A CHARACTERISTICS

Standard Operating Conditions	
Ambient Inlet Temperature	85°F
Ambient Inlet Pressure	29.92-in. Hg
Exhaust Pressure Loss	0.22 psi
Inlet Pressure Loss	0.02 psi
POWER PLANT DESIGN POINT CHARACTERISTICS	
Rated Power Output	140-hp
Torque @ rated 4570-rpm	160-lb/ft
Torque @ 0-rpm	370-lb/ft
Specific Fuel Consumption	0.51 lb/hp-hr
Compressor Air Flow	2.2 lb/sec
Compressor Pressure Ratio	4:1
Turbine Inlet Temperature	1700°F
Exhaust Temperature (full power)	400°F
Gas Generator Speed, Maximum	44,610-rpm
Power Turbine Speed, Maximum	45,730-rpm
Power Turbine Speed, Rated	39,000-rpm
Weight including accessories and gears	450-lb
Length, Width, Height:	
With Accessories and Gears	36-in; 35; 27
Without Accessories and Gears	27-in; 27; 25
Transmission for Vehicle Application	As required, but without free neutral
CURRENT FUELS	Unleaded gasoline, JP-4, Diesel Fuel, Kerosene and mixtures thereof.



STATUS REPORT:



13,750-kw machine set for the Oberhausen plant, which began operation in October 1960.

Solid-Fuel Gas Turbine Plants

by DR. CURT KELLER and W. GAEHLER*

Six plants with closed-cycle gas turbines burning solid fuels are demonstrating practicality, flexibility and high overall efficiency of this approach to electrical power generation. Four plants feature waste heat recovery for heating, further boosting overall efficiency.

Since 1956, six solid-fuel-fired plants, rated from 2 to 13.5-mw, have come into operation. Additional oil and gas-fired installations, both for stationary power plants and ship propulsion, have been built and operated or will soon start operation. Unfortunately, none of these are in the U. S. A status list as of the end of 1960 is given in Table 1.

Ravensburg Installation

The first industrial pulverized coal-fired plant started operation at the beginning of 1956 in Ravensburg, West Germany. It is a combined installation for power production and central heating (10,000,000 Btu per hr, max) in the form of 170/110-°F hot water. Since 1957, it has operated practically without trouble. Availability of this pioneer plant in the different years shows no interruption to service since 1958. Time for normal revisions and checks can be determined by the operator and is no longer dictated by difficulties with the plant.

The plant produces all power for an 1800-employee machinery work and the waste heat (hot water for space heating) is sufficient to heat the entire establishment, including office buildings, when ambient temperatures are as low as 0°F. By the end of 1960, the plant had achieved 24,650 hours of industrial service and produced over 31.6-million kw hr. Over 123-billion Btu of waste heat had been used for space heating and hot-water production.

The first pioneering small-scale tests with coal and peat-fired air heaters were made in 1950 and 1951 at the John Brown works, a licensee of Escher Wyss, at Clydebank, Scotland. In December, 1951, the first test gas turbine (500-kw) with a peat-fired air heater was started at these works (see May-June 1961 issue). Pulverised peat with an original moisture content of 50% was dried to about 25% moisture content by the flue gases, which had a temperature of about 660°F.

At the burner, moisture content of the peat was reduced to about 5 to 6% by the preheated combustion air. The test turbine ran some hundred hours, mostly with peat.

Based on the favorable results obtained with the John Brown test turbine it was decided to build a 2000-kw unit, the first industrial closed-cycle gas-turbine plant, at Ravensburg. This was a joint venture of Escher Wyss, the Gutehoffnungshutte, Sterkrade, and KSG, Kohlenscheidungsgesellschaft, Stuttgart.

* Abstracts from ASME paper 61-GTP-2 presented by the authors, both of Escher Wyss Ltd, Zurich, Switzerland, at the Gas Turbine Power Conference, Washington, D.C., March 5-9, 1961.

The power plant is extensively automated and requires only one man per shift for supervision, with another man for general help.

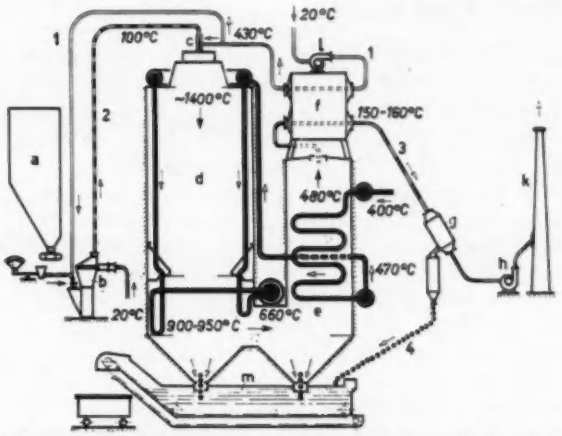
The plant was designed not only to work in parallel with the electric grid of the Energie-Versorgung Schwaben, EVS, but also to run independently as a sole source of the current needed by the factory. An average of about 1500-kw is needed during the day, with a peak load of 1800 to 2000-kw as contrasted to a peak load of about 700 to 800-kw at night. Load fluctuations are rather heavy and abrupt (± 200-kw). The regulating device is designed for sudden and unexpected interruptions in the EVS grid. The plant then adjusts automatically to supply only factory requirements and does this without any interruption of power delivery.

Air-Heater Design

Since this is the first industrial gas-turbine installation burning pulverized coal, layout of the air heater is rather conservative as regards specific combustion-chamber loading and tube stresses. This is also true of the recently built larger coal-fired air heaters listed in Table 1. This table also gives the main data for the radiation section of the air heaters. Main temperatures and pressures in the Ravensburg air heater are given for 2000-kw load in Fig. 1.

The Ravensburg air heater was the first for bituminous coal. The air heater for brown coal of the Moscow plant which started operation in September, 1960, is shown in Fig. 2. Erection of the tubes of one combustion chamber of the Oberhausen plant is shown. Accessibility of the single row of tubes is remarkable.

It is gratifying to report that design and operating difficulties of air heaters for closed-cycle plants were exaggerated. As in the case of high-temperature steel-tube heaters for chemical or refinery plants, prejudices of steamboiler designers had to be overcome first. Actually heater design and operation probably offer fewer problems for high-temperature service than modern steam-boiler practice. The relatively low-pressure level of closed-cycle turbines permits tube-wall and collector-wall thickness to be kept small and this reduces thermal



Schematic of the Ravensburg air heater, showing the principle temperatures: (1) combustion air; (2) pulverized coal; (3) flue gases; (4) ash:—(a) coal bunker; (b) coal mill; (c) burner; (d) combustion chamber; (e) convection chamber; (f) combustion air preheater; (g) ash separator; (h) flue-gas fan; (k) chimney; (l) combustion air fan; (m) ash extractor.

stresses. Only a fraction of the total heating surface is built in austenitic steels. In existing plants no very high-grade steels above 16 Cr-13 Ni type have been used.

At present, over-all size of an air heater differs little from a corresponding boiler because main dimensions are dictated by the necessary burning time and the path of the coal particles. Experience has shown that combustion of pulverized coal of different qualities is very good.

In an air heater, temperature of the preheated combustion air is higher than in steam boilers (about 750°F) and combustion wall temperatures of the radiant section are also higher than in a steam boiler. This helps to create ideal combustion conditions. Therefore, even small-capacity air heaters may work perfectly. For example, the Ravensburg plant can operate at part load—down to about 400 kw—on coal only, without supporting oil flame of any kind.

Escher Wyss heaters are designed for a life of about

(*continued on next page*)

Table 1 Main Data on Industrial Solid-Fuel-Fired Closed-Cycle Gas-Turbine Plants

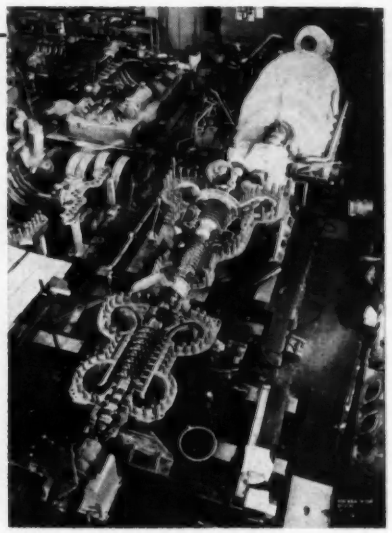
	Ravensburg, W. Germany	Coburg, W. Germany	Oberhausen, W. Germany	Moscow, Russia	Altnabreac, Scotland	Rothes, Scotland
Built by	EW/GHH	GHH	GHH/EW	EW	JB	JB
Purpose	E+H	E+H	E+H	E+H	E	E
Output, kw	2300	6600	13,750	10,000	2000	2000
Fuel, coal	Bitum.	Bitum.	Bitum.	Brown	Peat	Slurry
Lower heating value, Btu per lb	13,500	12,400	13,100	4500	5200	5900
Turbine-inlet temperature, deg F	1220	1255	1290	1255	1220	1220
Turbine-inlet pressure, psig	370	355	435	400	405	405
Heat production, normal, Btu per hr	7×10^6	26×10^6	65×10^6	...	...	...
Heat production, maximum, Btu per hr	12×10^6	55×10^6	85×10^6	32×10^6	...	...
Air heater tube dimensions, in.	1.3 x .1	1.3 x .13	1.3 x .11	1.6 x .16	1¼ x 0.1	1¼ x 0.1
Number of combustion chamber tubes	136	320	2 x 240	320	160	160
Combustion-chamber diameter, ft	9.7	15.2	2 x 14.1	17.7	9.9	9.9

E=Electricity, H=Heat, EW=Escher Wyss, JB=John Brown, GHH=Gutehoffnungshutte.

(continued from previous page)

100,000 hours at full load. Stresses in tubes are low (about 28-psi). Since there is no fluid in the air heater, it can be erected outdoors without danger of damage from freezing. Building costs are therefore reduced.

In Europe, and as far as is known in the U. S. also, an economic air or gas heater design is prevented by requirement to conform with boiler-code practice. The resulting design is too heavy and expensive—and without any technical reason. Design recommendations for chemical heaters are much sounder. In Europe, thin-wall alloy tubes can be applied since it has become obvious that working conditions are very different from those in boilers. No danger of explosion exists. Costs of European-built air or gas heaters are, therefore, much lower than those planned in the U. S. It is felt that application of existing requirements from an old field to a new development bans progress.



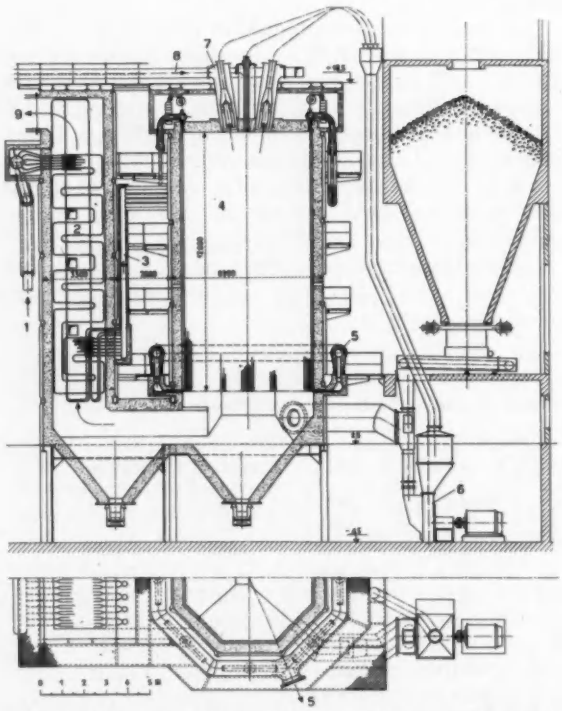
10,000-kw Moscow plant under construction at the Escher Wyss works.

Adaptability, Flexibility, Efficiency

Low cooling-water requirements and operational simplicity of isolated self-controlled plants will bring about more and more applications of closed-cycle gas-turbine plants in remote areas. Experience shows that the air heater can use low-grade fuel without difficulty. For self-contained plants with widely variable load, the variable pressure-regulation system applied in closed-cycle systems leads to high efficiencies not only at full load but also over a wide power range as compared with open-cycle gas turbines, in which efficiency falls relatively rapidly at reduced loads.

Furthermore, as load capacity is independent of ambient air temperature, nominal load capacity is available in winter as well as in summer. Thus, only plant efficiency depends on the cooling-water temperature which varies less than ambient air temperature. This is different with the open-cycle gas turbine in which maximum load capacity is considerably reduced in summer.

This fact has to be considered when evaluating the over-all economy of the plant. For bigger units both maximum efficiency and part-load efficiency will be appreciably higher.



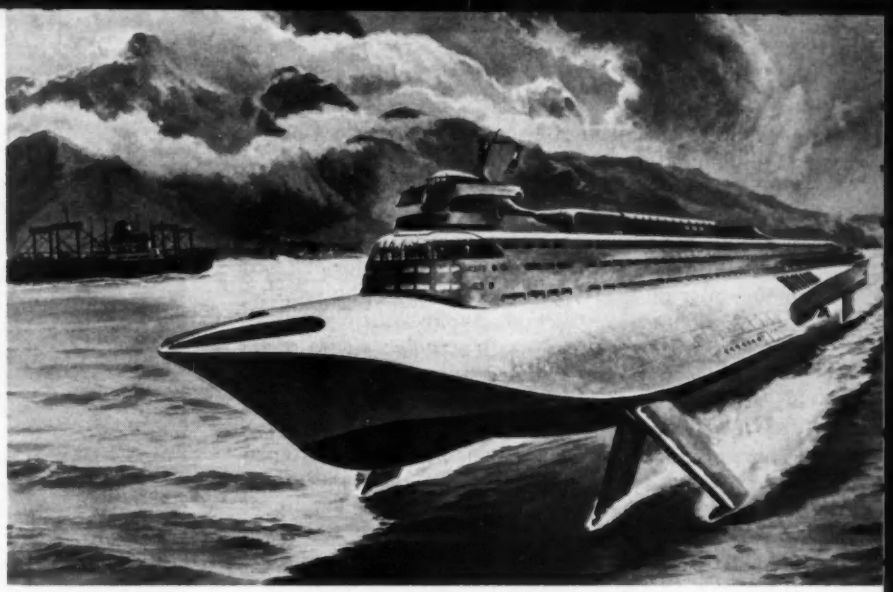
Pulverized-brown-coal-fired air heater for the 10,000-kw Moscow plant in cross-section. (1) from heat recuperator; (2) convection section; (3) connection tubes; (4) combustion chamber (radiation section); (5) to turbine; (6) coal mill; (7) burner; (8) combustion air preheater.

Power and Heating Combinations

Most of the coal-fired plants mentioned in Table 1 are used as combined power-production and central-heating installations. As cooling water from precoolers and intercoolers of the cycle can be made available at about 190°F, a unique heat source at convenient temperature level is provided for different industrial or domestic purposes.

It should be noted that in contrast to steam plants, heat extracted from the closed cycle at the aforementioned temperature is pure waste heat. By properly using the heat from coal for both electricity and heat production, over-all efficiency can be raised to 60 or 70%.

Central-heating schemes using waste heat are fast spreading in Western Europe and Russia. For combined power-production-and-heating systems, small and medium thermal power plants are best. Central heating is only economical when the distance of users from the power plant is not too great. In general, one kw, installed, may cover the needs of about one worker in industrial plants (Ravensburg, 1800-kw for 1800 people). About the same amount (1 kw or about 3400 Btu per hr) may be consumed for heating purposes. Therefore, a closed-cycle plant of say 25-mw electrical output will cover the needs of about 25,000 people with their families.



STAGE II

Power for "Flying" 80-ton Hydrofoil

Stage I, published in the March-April 1960 issue, described the 80-ton ship, together with details. Stage II is a progress report of this fine ship *. Stages III and IV will cover sea trials at a later date.

This ship is being built on a joint government and industry-financed project with industry participation by Grumman and Dynamic Developments and Associates, plus General Electric.

Full scale testing at sea will commence during this summer. In March, the General Electric main propulsion turbine was inspected by your Consulting Editor at Evandale, Ohio, when it was on the test stand getting ready for its series of final tests prior to shipment.

Description of Main Engine

The Model-240 engine consists of two basic sections, a gas generator and a free power turbine.

The prototype gas generator is a YJ79-2 modified for sea duty. (For production the CJ-805 gas generator will be used) Air is drawn into the engine on a day of 80°F at a flow rate of 159 lb/sec at 100% gas generator speed (7460 RPM) and compressed by a 17-stage axial flow compressor. Operating at a 12:1 pressure ratio, the compressor discharges air to a set of 10 annular combustion chambers. From the combustion chamber, hot gas flows through a 3-stage gas generator turbine. This turbine provides power to turn the gas generator compressor since both are on a common shaft. On leaving the gas generator, hot gas flows through a single-stage power turbine where remaining energy is converted to shaft horsepower. Only an aerodynamic bond ties gas generator and power turbine rotors together, although outer casings of each are joined to form a single unit.

Exhaust gas from the power turbine discharges at an angle of 45 deg to the horizontal. Control of power turbine speed is accomplished by regulating fuel flow to the gas generator. Fuel flow is regulated by a hand throttle, but can be overridden by a torque motor device in the fuel control which receives a d-c signal proportional to turbine speed error. This d-c signal originates from an alternator system geared to the power turbine and will hold any selected turbine speed (between 3900 and 5500 rpm) automatically, regardless of load variations. A mechanical overspeed trip is available for engine shutdown at preselected power turbine speeds.

On a day of 80°F, continuous rating of the engine is 14,000 shp with a specific fuel consumption of 0.55 lb/hp/hr and a power turbine speed of 5500 rpm. Also on an 80°F day and on a limited basis of 5.0 minutes each hour, 16,800 hp is available with an SFC of 0.53 lb/hp/hr at a power turbine speed of 6050 rpm.

Air reaches the Model-240 bellmouth through a devious path. Particular attention has been given to

(continued on page 28)

* *Much of this information was obtained directly from SAE paper no. 355C by Glan J. Wennagel of Dynamic Developments, Inc., presented in New York April 4-7, 1961.*

(Continued from page 27)

maximum water removal in order to reduce to a practical minimum the quantity of sea salts drawn in with the combustion air. High salt content could result in compressor blade fouling and also contribute to corrosion of turbine hot parts.

Initial air entry is through water separators located in the sides of the superstructure above the weather deck. Separator construction employs many vertical, sharply corrugated louvers with scrubber ridges to remove water droplets. Separated water drains vertically, in catchment trays incorporated on each louvre, and then overboard through a piped drainage system.

The interior of the plenum chamber gives additional protection against water; the engine bellmouth protrudes into a boxed area enclosed by 5-ft high walls on all sides. Once inside the plenum, air must flow over the walls and enter the boxed area from the top prior to reaching the inlet bellmouth. Separator drains and interior plenum drains have a water removal capacity of 1170 gpm. Screening, with 5/16 in. mesh, offers protection from foreign objects. Maximum air velocity through the separator is 33.5 fps, maximum velocity in the plenum interior is 44.0 fps.

Engine design has incorporated many anti-corrosive measures, in the form of element coatings and material selection, for operation in a salt water environment.

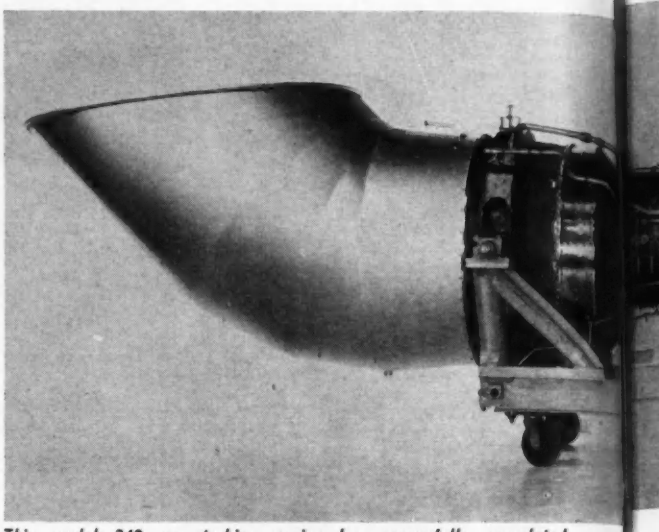
Starting of the engine is accomplished by an air turbine starter mounted on the bullet nose of the gas generator. Air is supplied to the starter from two APU's (described later) at a flow rate of 85 lb/minute, 34 psi, and a temperature of 345°F. The ignition circuit commences firing as soon as air is supplied to the starter. Fuel is metered into the combustion chambers by throttle movement and engine light off is in the 16-20% rpm range.

Fuel control of the main engine (Model-240) is throttled by hand levers and push-pull cables. A power turbine shaft disc brake is controlled by hydraulic power and a solenoid-operated 3-way valve. Pilothouse controls are at the captain and first officer control stations.

The main engine transmission consists of six basic sections: upper deck shafting, a single idler reduction gear box, lower deck shafting, an upper strut bevel gear box, vertical strut shafting, and a lower bevel gear box in the propeller pod. A turbine output shaft torquemeter and a propeller shaft thrust meter form an integral part of the transmission design. Transmission and gearing described above are from General Electric's "Medium Steam Turbine Generator and Gear Department," making it a completely integrated G.E. propulsion system.

Description of "Displacement Condition" Engine

This small turbine is used to power the ship when maneuvering and operating otherwise as a displacement vessel. This is a GE turbine, the Model 720 which consists of three basic sections: a gas generator, a free turbine, and an integral reduction gearbox. An extensive marinization of this engine has been accomplished through component platings, coatings and material substitution which provide necessary protection in a salt laden atmosphere.



This model 240 gas turbine engine has successfully completed qualification testing at General Electric's Large Jet Engine

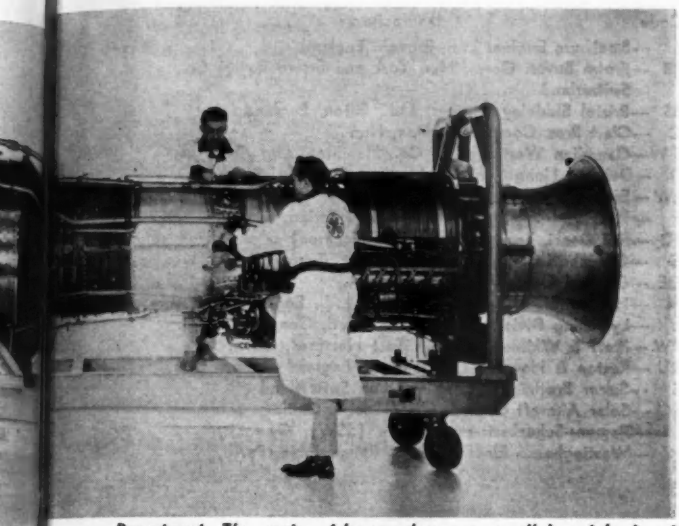
On an 80°F day, air is drawn into the engine at a maximum rated flow of 11.9 lb/sec at 100% gas generator speed (26,300 rpm), is compressed by a 10-stage axial flow compressor operating at a 7.5 to 1 pressure ratio and is discharged to a single annular combustion chamber. From the combustion chamber, hot gas flows through a 2-stage gas generator turbine. Upon leaving the gas generator, the hot gas flows through a single stage power turbine where remaining energy is converted to shaft horsepower. Only an aerodynamic bond ties the gas generator and power turbine rotors together, although outer casings of each are joined to form a single unit.

An integral reduction gear reduces power turbine rpm by a factor of 3.25. Nominal rpm of the power turbine is 19,500 (93%) which results in an output shaft speed of 6000 rpm. Exhaust gas from the engine discharges in the horizontal plane at a 60° angle toward the port side of the craft and is then directed vertically upward and overboard through the weather deck.

Power turbine speed is regulated by means of a manual throttle which in turn regulates an engine fuel control. An emergency throttle is also provided in case of a fuel control malfunction. Fuel flow is controlled manually by the throttle from idle to approximately 85% power turbine rpm. Above this range, the control will automatically vary fuel input to maintain a desired power turbine speed. Engine design also incorporates a mechanical overspeed governor to limit speed to 100% of maximum rpm and a mechanical trip for fuel shut off at speeds above the 100% value.

On an 80°F day, the engine has a continuous rating of 765 hp with an SFC of 0.71 lb/hp hr and at a shaft output speed of 6000 rpm.

Starting the engine is accomplished by an air turbine starter mounted on the bullet nose of the gas generator. Air is supplied to the starter from two APU's (described later) at a flow rate of 60 lb/minute, 40 psi, and a temperature of 300°F. The ignition circuit commences firing as soon as air is supplied to the starter. At an engine



Department. The engine (shown, above, on cradle) weighs in at 6600 pounds, developed 19,000-hp at 5500-rpm during test runs.

speed of approximately 10% gas generator rpm, the engine throttle is advanced and light off occurs in the 10%-15% rpm range.

A transmission for displacement operation is capable of absorbing 1250 hp at 6000 rpm from the Model 720 main reduction gear. Attachment to the reduction gear is through a splined quill shaft. This shaft drives into a gear box where right angle, spiral bevel gearing splits power to two output shafts which run athwartship, one to port and one to starboard. Maximum output shaft speed is 2250 rpm.

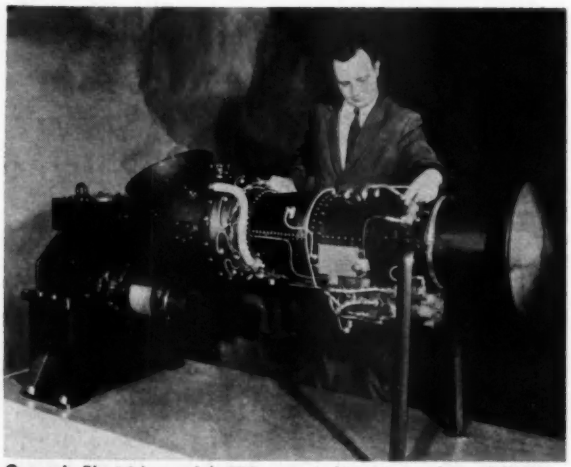
APU AiResearch Units

The generators are high-speed, lightweight, aircraft type rated 60 kva, 120/208 v, 0.75 power factor, 400 cycle at 6000 rpm. These are driven by AiResearch gas turbine compressor and power units, GTCP 85-91 each rated 200 shp. Overload rating of the generators is 200% for 3.0 seconds and 150% for 3.0 minutes. Tests show a capability by supplying 80 kva for a period of 15.0 minutes without generator overheating. Generators are cooled by forced air ventilation provided by a fan mounted on each turbine.

Each generator is capable of supplying the normal operating load requirements of the vehicle thereby providing 100% standby. Under extreme conditions, load can be divided between generators, utilizing a split bus. Generator controls are remotely located in the engineer's console and consist of voltmeter, ammeter and wattmeter for each generator plus a common frequency meter. Switches are provided for generator power transfer and bus control.

In addition to operating the generator each unit delivers bleed air for:

a. Heating the pilot house and inhabited areas below deck.
b. Powering the air conditioning unit for the pilot house.
c. Windshield defrosting.
4. Delivery to topside outlets for snow and ice removal.
e. For starting the main turbine (240) and displacement turbine (720).



General Electric's model 720 gas turbine is used as "displacement" engine. It is used when bigger model 240 engine is shut down, for maneuvering or general low-speed running.

Fuel System

Fuel is JP-5 carried in four tanks, two on the starboard side and two on the port side. Maximum fuel capacity is 9386 gal. Suction for fuel booster pumps is normally taken from the forward tank on the port side. A transfer system allows fuel transfer from the other tanks to the normal suction tank.

A booster pump for the Model 240 main engine can deliver fuel at a rate of 30 gpm and at 50 psi through a filter and flowmeter. An electric motor-operated gate valve is located in the fuel line near the engine and provides a remote shutoff from the engineer's control station. For emergency shut down, the valve is located such that a minimum of fuel in the supply line is available for continued burning after shutoff. A similar arrangement of filter, flowmeter, and motor operated gate valve is provided between the Model 720 displacement engine and a separate fuel booster pump. This pump can deliver 5 gpm.

For the Future

The ship will be launched this summer and sea trials are scheduled to start in the fall. The present construction includes subcavitating hydrofoils for speeds up to 60 knots. When these tests are completed a new set of hydrofoils will be installed (1962) to allow operating speeds up to 80 knots.

At this time the Maritime Administration is soliciting proposal for future commercial operation of this high speed craft. Selection of a commercial operation will probably be made in the near future.

All concerned, including Dynamic Developments Inc. (and the Grumman Aircraft Engineering Corp.) under contract to the U. S. Maritime Administration, should be congratulated on pushing these tests to the utmost.

BIG GAS TURBINES

1961's List of gas turbine installations, like the 1960 listing, is world-wide in scope. However, the lower power limit has been reduced to 1000 horsepower. Thus, this list covers some mass-produced units with the higher-horsepower tailor-made models. This comprehensive new list supplements the one published in the July-August 1960 issue; there are no repeats except for a few noted corrections.

We encourage manufacturers, operators and readers to advise us of any additions or changes that should be made. We want this listing as complete and useful as possible so additional data or constructive suggestions will be appreciated.

LET US REPEAT FROM LAST YEAR

The list tells its own story . . . a magnificent record of achievement of which the gas turbine industry can be proud . . . a record others must note and respect . . . a record that shows

THERE IS A GAS TURBINE INDUSTRY!

SOME TOTALS

Items	Lists #1	Lists #2	Total
Manufacturers reporting Sales	24	19	32
Units—Total	592	156	748
MW Capacity as listed	2319.42	505.57	2824.99
MW Capacity as listed Converted to HP	3,407,080	735,427	4,142,507
HP as listed	2,264,100	463,893	2,727,993
Grand Total, HP	5,671,180	1,199,320	6,870,500

***NOTE:* #1 list of July-August 1960 issue, #2 list this issue. This does not include the 1000-1799 hp range prior to 1960 of which there are only a few except Ruston & Hornsby 1260 hp units.**

Code Identifying Manufacturers

Code	Manufacturers
B	—Blackburn Engines Ltd., Brough, England
BB	—Brown Boveri Corp., New York and Brown Boveri Co., Switzerland
BS	—Bristol Siddeley Engines, Ltd., Filton, England
C	—Clark Bros. Company, Olean, N. Y.
CW	—Canadian Westinghouse Co., Hamilton, Ontario
D	—DeLaval Ljungstrom Turbine Co., Finspang, Sweden
EW	—Escher Wyss, Zurich, Switzerland
F	—FIAT Stabilimento Grandi Motori, Torino, Italy
FD	—Fuji Denki, Tokyo, Japan (EW Licensee)
G	—Gutenhoffnungsh Hutte, Sterkrade, Germany (EW Licensee)
GE	—General Electric Company, U.S.A.
H	—Hawker Siddeley Brush Turbines Ltd., England (C Licensee)
L	—Lycoming Division, AVCO, Stratford, Conn.
PW	—Pratt & Whitney Aircraft, East Hartford, Conn.
RU	—Ruston & Hornsby Ltd., Lincoln, England
S	—Sulzer Brothers Ltd., Winterthur, Switzerland
SO	—Solar Aircraft Company, San Diego, Calif.
SS	—Siemens-Schuckertwerke A. G. (SSW), Germany
W	—Westinghouse Electric Corp., Philadelphia, Pa.

LEGEND

Note: Entries in "Heat Exchanger" column show heat exchangers used for heating, cooling or both. When two or more identical turbines are listed on a single line, "Rating" applies to single units. Also, under "Rating, Maximum", rating given was used when supplied, converted to horsepower if necessary. When only "Normal" rating was supplied in "MW", conversion was made. All conversions were made on basis of MW/0.7, accounting for generator efficiency.

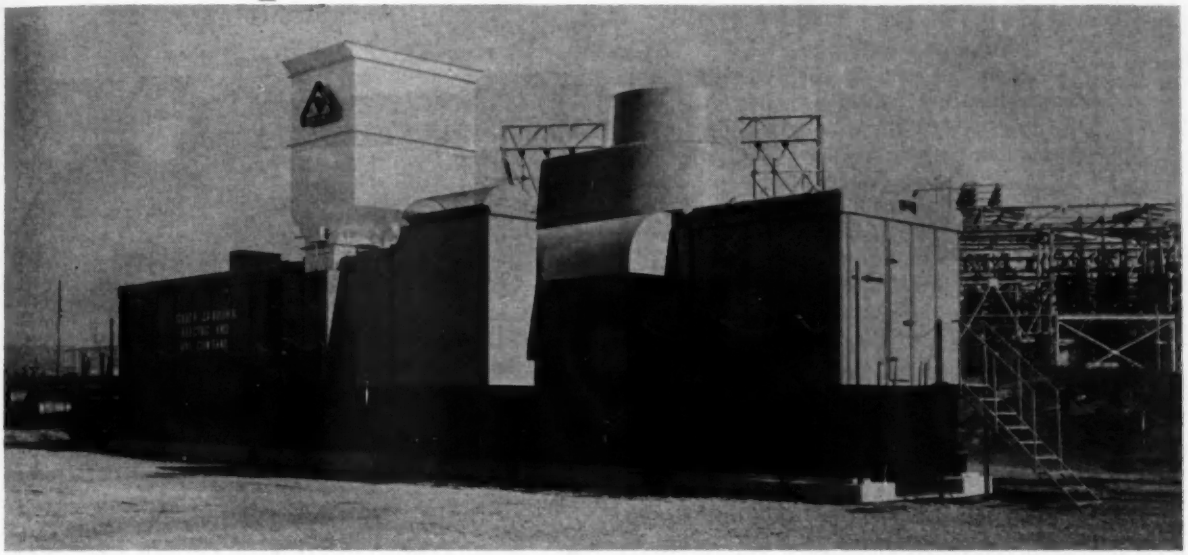
AC—Air Compressor Drive
BFG—Blast Furnace Gas Fuel
C—Coal Fuel
CC—Closed Cycle
CH—Central Heating
CO—Crude Oil Fuel
D—Diesel Fuel Oil
DY—Dynamometer
FP—Fracturing Pump
G—Gas Fuel
GC—Gas Compressor Drive
Gen—Generator Drive
H—Exhaust Heat Exchanger
hp—Horsepower
IC—Intercooler
L—Liquid Fuel Oil
LCA—Landing Craft
LM—Locomotive
LVH—Amphibious Vehicle (Hydrofoil)
LVW—Amphibious Vehicle
M—Shipboard Use
MW—1-Million Watts
NG—Natural Gas Fuel
OP—Oil Pump Drive
SG—Sewage Gas Fuel
T—Tank
WD—Water Distillation

OPERATING OR PURCHASING COMPANY LOCATION OF INSTALLATION	NO.	MFGR.	YR.	USE	NO. SHAFTS	HEAT EX.	TYPE FUEL	RATING NORMAL	RATING MAX
Agua y Energia Electrica, Argentina									
Blanco Encalada, Argentina	2	F	61/62	Gen	1	—	L	6.4MW	—
Mobile Plant (Argentina)	2	F	61/62	Gen	1	—	G, L	6.4MW	—
American Independent Oil Company, Ltd.									
Kuwait	4	RU	61	Gen	2	—	NG	1260hp	—
American Oil Company									
USA	2	GE	61	GC	1	H	G	14,200hp	—
Anglo Ecuadorian Oilfields, Ltd.									
Ancon, Ecuador	1	RU	61	Gen	2	—	NG	1260hp	—
Arabian American Oil Company									
Khursaniya, Saudi Arabia	4	RU	60	OP	2	—	CO	1260hp	—
Safaniyah, Saudi Arabia	1	RU	61	OP	2	—	NG	1260hp	—
Saudi Arabia	3	GE	61	Gen	1	—	L, G	10.25MW	14,700hp
Atnor									
Argentina	1	GE	61	Gen	1	—	—	5.5MW	7900hp
Celera Avellaneda, S.A., Buenos Aires									
Olevarria, Argentina	1	S	62	Gen	1	H	L, G	6.1MW	8750hp
Central Electricity Generating Board									
Birmingham, England	1	BS	—	Gen	3	—	D	15MW	21,500hp
Central Vermont Public Service									
Vermont	2	GE	61/62	Gen	1	—	D	10.75MW	15,400hp
Champlin Oil and Refinery									
Enid, Okla.	2	CRU	60	GC	2	—	NG	1220hp	—

OPERATING OR PURCHASING COMPANY LOCATION OF INSTALLATION	NO.	MFGR.	YR.	USE	NO. SHAFTS	HEAT EX.	TYPE FUEL	RATING NORMAL	RATING MAX
Dortmund-Horder-Huttenunion									
Dortmund, Germany	1	SS	60	AC	1	H	BFG	7500hp	9050hp
El Paso Natural Gas Products Company									
Odessa, Texas	1	W	61	GC	2	—	NG	6500hp	—
Odessa, Texas	1	W	61	GC	2	—	NG	8500hp	—
Electricite et Gaz d'Algerie									
Hassi r' Mel, French Sahara	2	F	62	Gen	1	—	G, L	6.4MW	—
Empresas Electricas Associadas									
Santa Rosa, Lima, Peru	1	BB	61	Gen	2	IC	L	22.2MW	31,857hp
Hartford Electric Light Company									
Hartford, Conn.	1	PW	62	Gen	3	—	D	10MW	13,800hp
Houma (City of), Louisiana									
Houma, La.	1	W	61	Gen	1	—	NG, D	12MW	17,200hp
Hudson Gas and Oil Company									
Houston, Texas	1	W	61	GC	2	—	NG	6500hp	—
Indupa S.A.I.C.—Argentina									
Cinco Saltos, Argentina	1	F	61	Gen	1	—	G, L	6.4MW	—
Iran Oil Services									
Umadieh, Iran	2	RU	60	OP	2	—	NG	1260hp	—
Umadieh, Iran	1	RU	61	OP	2	—	NG	1260hp	—
Iraq Petroleum Company, Ltd.									
Iraq	9	RU	61	OP	2	—	NG	1260hp	—
Syria	6	RU	61	Gen	2	—	NG, D	1260hp	—
	4	H	—	OP	2	—	L	9300hp	—
Kansas-Nebraska Natural Gas Company									
Lakin, Kansas	1	W	61	GC	1	—	NG	4200hp	—
Kuwait Oil Company, Ltd.									
Kuwait	2	RU	60/61	Gen	2	—	NG	1260hp	—
Loma Negra S.A.—Argentina									
Barker, Argentina	2	F	61	Gen	1	H	G, L	5.85MW	—
London County Council									
Beckton, England	8	RU	60	Gen	2	CH	SG, D	1050hp	—
Konig Ewald Ludwig Mining Cie.*									
Haus Aden, Germany	1	EW-G	62	Gen	1	CC, CH	C, G	6MW	9500hp
*1960 List corrected									
Nacional Financiera S.A. Empresas Electricas									
Mobile Plant (Mexico)	1	BB	60	Gen	1	—	L	6.4MW	9200hp
Nippon Kokan K.K.*									
Japan	1	FD	61	Gen	1	CC	BFG	10MW	17,200hp
*1960 List corrected									
Northern Natural Gas Products Company									
Bushton, Kansas	2	W	61	GC	1	—	NG	8000hp	—
Nova Cap									
Brazil	2	GE	61	Gen	1	—	CD	5.3MW	7,700hp
Oasis Oil Company of Libya									
Libya	3	RU	61	Gen	2	WD	CD	1260hp	—
Okan Pipeline Company									
Goaltry, Oklahoma	1	SD	61	OP	2	—	L	800hp	1100hp
Oklahoma Gas & Electric Company									
Oklahoma	1	GE	63	Gen	2	H	NG	25MW	35,900hp
Pacific Gas Transmission Company									
Sands Point, Idaho	1	W	61	GC	2	H	NG	6000hp	—
Pacific Telephone and Telegraph Company									
Oakland, California	1	GE	61	Gen	2	—	D	1125hp	1238hp
Park Plaza									
Little Rock, Arkansas	1	C-RU	60	Gen	2	H	NG	0.865MW	1220hp
Petroleos Mexicanos									
La Venta, Mexico	1	BB	60	Gen	1	—	NG	6.4MW	9200hp
Philadelphia Electric Company									
Norristown, Pa.	1	GE	61	Gen	1	—	G, D	20.5MW	29,400hp
Phillips Petroleum Company, Ltd.									
San Roque, Venezuela	1	RU	60	Gen	2	—	NG	1260hp	—
Quebec Hydro Electric Commission									
Quebec, Canada	6	GE	60	Gen	1	—	D	5.5MW	7900hp
Royal Navy, England									
(Training)	1	RU	—	Dy	2	—	D	1260hp	—
(Ship-borne)	2	RU	60	Gen	2	—	L	1260hp	—
Roumanian Ministry for Oil & Chemical Industry									
Barbatesti, Roumania	1	S	62	GC	2	H	G	4000hp	—
Ticleni, Roumania	1	S	62	GC	2	H	G	4000hp	—

OPERATING OR PURCHASING COMPANY LOCATION OF INSTALLATION	NO.	MFGR.	YR.	USE	NO. SHAFTS	EX. HEAT	TYPE FUEL	RATING NORMAL	RATING MAX
Saunders Roe, Isle of Wight** (Hovercraft) **Two Nimbus 901's coupled	1	B	61	AC	4	—	L	1000hp**	—
Sewage and Water Board New Orleans, Louisiana	1	GE	61	Gen	1	—	G, D	20.2MW	29,000hp
Sierra Pacific Power Company Reno, Nevada	2	W	61/62	Gen	1	—	D	12MW	17,200hp
Societa Idroelettrica Piemonte, Italy Chivasso, Italy	1	F	61	Gen	1	IC	G, L	32MW	—
Societe Petroliere de Gerande, Algeria Haoud el Hamra, French Sahara	2	F	60	Gen	1	—	G, L	6.4MW	—
South Carolina Electric and Gas Company South Carolina	4	GE	61/63	Gen	1	—	G, D	10.75MW	15,400hp
South Western Electricity Board Lynton, England	1	BS	60	Gen	2	—	D	4250hp	—
Stadtwerke Munchen Munchen-Sendling, Germany	1	SS	61	Gen	1	CH	NG, L	22MW	39,000hp
Sun Oil Company Laverne, Oklahoma	3	C-RU	60	Gen	2	H	NG	0.865MW	1220hp
Laverne, Oklahoma	1	C-RU	—	Gen	2	H	NG	0.865MW	1220hp
D.X. Sunray Company Oklahoma	1	GE	60	GC	1	H	G	7500hp	—
Tennessee Gas Transmission Company* Alexandria, Louisiana *1960 List corrected	2	GE	58/59	GC	2	H	NG	6700hp	—
Tennessee Pipeline Company Leeville, Louisiana	1	SD	61	GC	2	—	NG	1040hp	1100hp
Texaco Port Arthur, Texas	1	W	61	GC	2	—	NG	6000hp	—
Texas Eastern Transmission Corporation	3	GE	61/62	GC	2	H	NG	8000hp	—
B.P. Trading, Ltd. Das Island, Persian Gulf	2	RU	61	DP	2	—	NG	1260hp	—
Trans-Canada Pipe Lines, Ltd. Grenfell, Saskatchewan	1	CW	60	GC	2	—	NG	8500hp	—
Portage La Prarie, Manitoba	1	CW	60	GC	2	—	NG	8500hp	—
Rapid City, Manitoba	1	CW	60	GC	2	—	NG	8500hp	—
Trunkline Gas Company Cypress, Texas	1	SD	61	GC	2	H	NG	1040hp	1100hp
Union Carbide Seadrift, Texas	1	C	—	GC	1	—	NG	9000hp	—
Union Pacific Railroad	17	GE	60/61	LM	1	—	L	8500hp	—
United Fuel Gas Company Spencer, West Virginia	1	SD	61	GC	2	—	NG	1040hp	1100hp
U.S. Army OTAC (Ordnance)	1	SD	61	T	2	—	L	600hp	1100hp
TC (Transportation Corps) (land train)	4	SD	61	Gen	1	—	L	1000hp	1100hp
U.S. Coast Guard Curtis Bay, Maryland	1	SD	61	M	2	—	L	1040hp	1100hp
U.S. Government* *1960 List corrected	1	C	61	Gen	2	—	L	6.75MW	9700hp
U.S. Maritime Administration Hydrofoil, 80-ton (propulsion)	1	GE	61	M	2	—	D	14,000hp	20,000hp
Hydrofoil, 80-ton (auxiliary power)	1	GE	61	M	2	—	D	1250hp	—
U.S. Lines	1	SD	61	Gen	1	H	L	0.6MW	1100hp
U.S. Navy Bureau of Ships	1	L	62	LVW	2	—	L	1500hp	—
Bureau of Ships	1	L	63	LVH	2	—	L	1225hp	—
Bureau of Ships	1	SD	61	LCA	2	—	L	1040hp	1100hp
U.S.S. Oklahoma City	1	SD	60	Gen	1	—	L	0.75MW	1100hp
Venezuela State Power Company Lake Maracaibo, Venezuela	3	D	62	Gen	3	—	NG	7.5MW	10,700hp
Western Company Houston, Texas	1	SD	60	FP	2	—	L	1100hp	—
Yacimientos Petroliferos Fiscales, Argentina Lujan de Cuyo, Argentina	1	F	61	Gen	1	—	G, L	6.4 MW	—
Pico Truncado, Argentina	2	F	61	Gen	1	—	G, L	6.4 MW	—

GT powered / power package



First GE gas turbine package power plant, this 11-250-kw unit, has been sold by GE's Gas Turbine Dept. to South Carolina Electric and Gas Co. for installation at Burton.

Multi-purpose transportable unit priced at $85/kw

General Electric gas turbines are setting records for both reliability and availability while accumulating operating experience at the rate of almost 100,000 hours per month. Total operating hours exceed 5,600,000.

The application flexibility of the gas turbine to electric utilities and industrial processes has been well proven in the little more than 10 years since the first gas turbine was introduced.

G-E's newest gas turbine application, the package power plant, NEMA rated 11,250-kw, fulfills the following objectives required for optimum peak load generation.

(1) Low installed cost.
(2) Site location flexibility.
(3) Automated-remote-control, unattended operation.
(4) Units sized for effective dispatching and control.

Only the gas turbine meets all these requirements with a single prime mover. Dramatic improvements in low installed cost have resulted from packaging, standardization and increased output per unit size.

Packaged plants are 95% equipment, 5% installation cost. This allows 95% of the total installed cost to receive the cost advantages of design standardization, repetitive manufacturing and volume production.

The 11,250-kw package power plant consists of three basic elements: power unit, generator unit and associated switchgear, with optional items such as remote supervisory equipment, inlet filter, evaporative cooler and job crane. Pre-assembled at the factory, these basic elements can be installed and in operation in as little as 10 days after arrival of the equipment at the site.

These gas turbine package power plants are ideal for short-duration load applications such as peaking, end-of-line, emergency standby and firming auxiliary power supply to steam plants. The plant also can be applied in base-load service combined with conventional steam generation equipment to improve overall station efficiency. Both the single cycle and a regenerative cycle arrangement of the package concept are available.

Overall dimensions of the installed package power plant are approximately 80-ft long, 22-ft wide and 16-ft high.

The design is suitable for operation at ambient temperatures from −40 to 120°F. It is completely self-cooled, eliminating need for an external cooling water supply—thereby permitting maximum site selection flexibility. The plant's acoustic treatment permits operation in a suburban area.

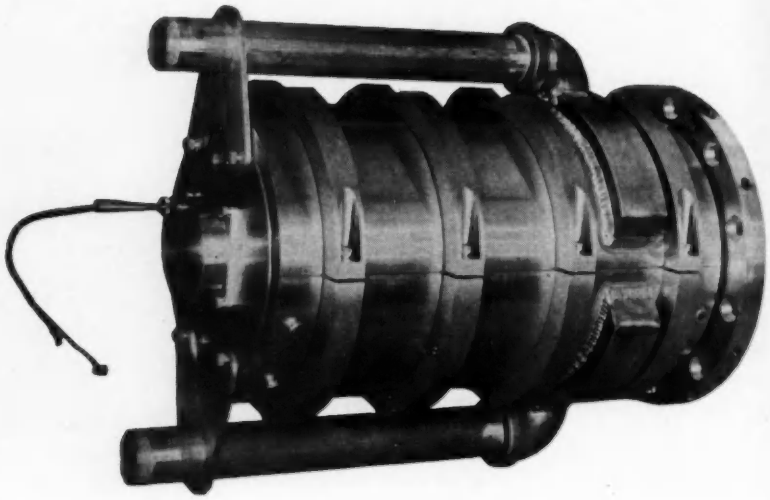
The package is mounted on a simple foundation. Two "I" beams running the full length of the foundation act as rails to facilitate moving the units into position during erection. A simpler foundation can be used where a crane is available. The unit can be started without external auxiliary power thereby providing maximum protection during emergency service.

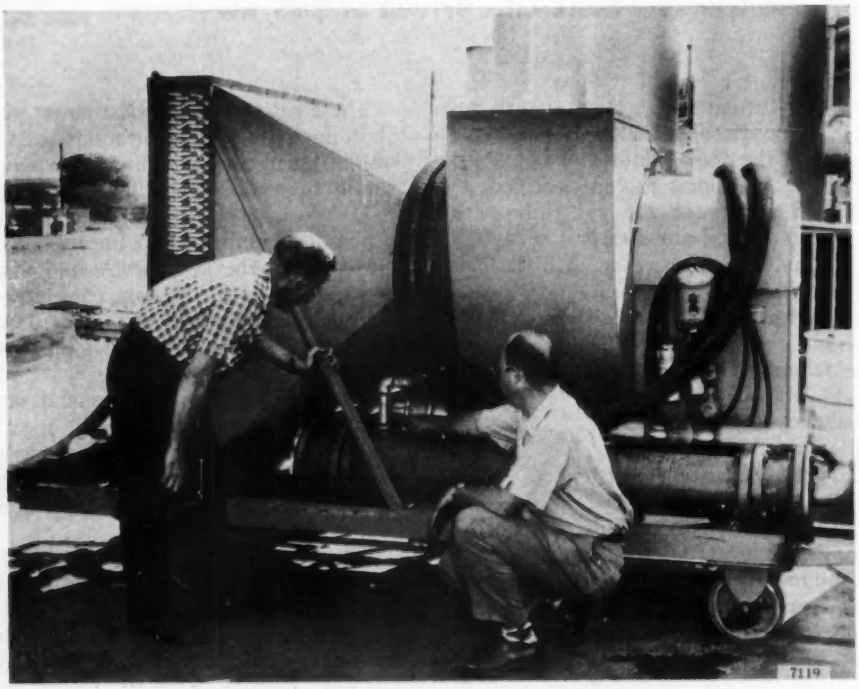
When blocks of more than 11,000-kw are required, multiple units can easily be installed. For example, South Carolina Electric and Gas Company has just purchased four of the units. This purchase, in conjunction with the natural gas transmission lines SCE&G has recently installed, enables the company to capitalize on the gas turbine's versatility to help assure a continuous supply of low-cost power.

GT PRODUCT NEWS

Kahn Water Brake

Kahn & Company has designed and is producing a water brake (absorption dynamometer) to take the shaft horsepower of engines, gas turbines and other rotating machinery. When used with suitable power measuring equipment it becomes an economical and versatile method of measuring power output. Brakes are available in seven basic models with maximum power absorption of from 1000-hp @ 20,000-rpm to 8000-hp @ 10,000-rpm.





Portable Air Conditioner Solves Gas Turbine Test Problems

A portable air conditioner unit has been developed by AiResearch engineers to solve the problem of inlet temperature control in testing gas turbine engines in the intense summer heat at Phoenix, Arizona. The cart-mounted air conditioner unit is made up from an AiResearch air-driven cooling turbine assembly on the right, in combination with American-Standard equipment: a packaged motor fan unit, a chilled-water coil unit and an air-to-water shell-and-tube heat exchanger. Produces 60° inlet-air temperature for testing the gas turbines.

Maintenance "Watchdogs"

To design ease of maintenance into the U. S. Army's powerful new HC-1B Chinook twin turbine powered helicopters, Boeing's Vertol Division established a five-man "watchdog team".

Five Vertol field service representatives reviewed designs in the layout stage and suggested maintenance design changes on 150 items. 85% of these were incorporated in the final design of the Chinook, according to Vertol's L. J. Geier, Supervisor, Service Engineering, and G. M. Powell, Jr., Chief Material and Reliability Engineer.

723

Rapid Progress on PT6

Emphasizing the stepped-up momentum of its 500-hp PT6 free turbine engine program, Canadian Pratt & Whitney Aircraft set May dates for the first flight of the turboprop version of the engine and the start of ground-running tests in a new Hiller helicopter for the turboshaft configuration.

Installed in the nose of a modified Beech 18, the PT6 has already undergone rigid ground-running tests to check out the "flying test bed" installation. Hiller Aircraft will run similar tests for the rotocraft installation this month.

Announcement of the flight and ground running tests follow less than a month after the successful completion of a company 50-hr. test of the 500-hp. PT6. In addition, the engine has demonstrated its guaranteed ratings and has in excess of 1200-hrs. of full-scale running time.

Developed by United Aircraft Corporation's Canadian subsidiary, the PT6 (U. S. military designation T74) is a lightweight engine with a wide variety of applications. The turboprop, aimed at light to medium single and multi-engine aircraft, including VTOL, weighs in at 250-lbs, while the turboshaft, now under study by most major helicopter manufacturers, weighs only 225-lbs.

Progress on the PT6 has been rapid. First studies were made in the Autumn of 1958, with detailed design starting in early 1959. Testing of the gas generator section of the engine commenced in November 1959. The complete engine first operated in February 1960. Since that date, a steady increase in development testing has taken place. In December 1960, dynamometer calibration confirmed the sea level performance guarantees.

724

Centrifugal Throw-Out Clutch Protects Turbine Starter

First put into use during the past year, newly designed and improved turbine starter drives with greatly increased wearability now give considerable promise of removing jet engine starters from the "headache list" of ground maintenance men and designers for a number of reasons.

Failure to disconnect the starter quickly from the turbine by means of over-running clutch means almost certain and often irreparable damage to starter equipment. Turbine speeds, which range up to 35,000-rpm, are ruinous to starters. Consequently, the over-running clutch has become mandatory as the instrument for disconnecting the turbine from the starter.

Designers have developed a durable and reliable starter which will neither wear out quickly nor rip apart as the turbine winds up to its astronomical operating speed.

The new design, called a "centrifugal throw-out clutch" allows the sprags to lift completely clear of contact with the inner race during over-running through the application of centrifugal force. It forces the sprags to hug the outer race when they are not serving to transmit driving torque.

The design (patented) is an exclusive development of the Formsprag Company, Warren (Detroit), Michigan, producers of precision power transmission products.

Based on their applications to date, centrifugal throw-out sprag clutches enable designers to eliminate the need for disconnect devices between the starter and the turbine. At the same time, they climinate all possibility of wear, contributing to greater field durability as well as increased performance reliability.

725

J-58 Airfoils

TAPCO of Thompson Ramo Wooldridge reports doubling the production requirements for rotor and stator blades of P&WA's J-58 high speed jet.

726

PRECISION Turbine Components

Creative engineering, experience and specialized production facilities at Poly Industries assure the highest degree of precision in manufacturing gas turbine components. Complete facilities for experimental or high production quantities of turbine blades, vanes, wheels and nozzles. Techniques for machining and forming with the toughest alloys of exotic metals are a specialty of Poly Industries.

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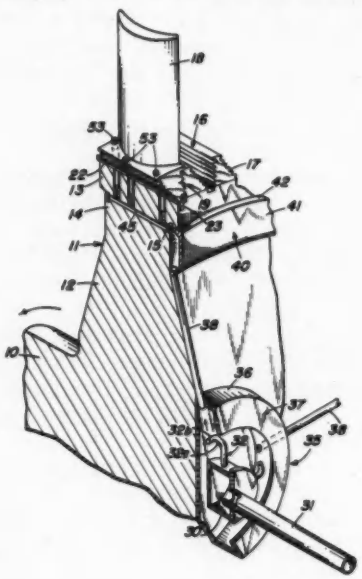
GT PATENTS

By J. W. Sawyer

EXTERNAL LIQUID-SPRAY COOLING OF TURBINE BLADES (2,974,925) 7 CLAIMS John C. Freche, Fairview Park, and Roy A. McKinnon and John M. Braschwitz, Cleveland, Ohio assignors, by mesne assignments, to the United States of America as represented by the Administration of the National Aeronautics and Space Administration. Provides a blade cooling means for gas turbine blades, the entire blade area, regardless of the blade dimensions. The gas turbine structure includes the rotor shaft (10) terminating in hub (11). The hub rim (13) is formed with a continuous series of transverse recesses (16), each of which is broadly V-shaped but having the side wall formed with adjacent secondary transverse grooves (17). Blade attachment is made by sliding the blade root (19) into the rim recesses (16) from the hub side and secured by locking strap (22). With rotation of the turbine rotor coolant fluid flows through inlet pipe (31) into the stationary supply manifold (30) and is forced out into the annular gutter (35) through nozzle (32). Centrifugal force is operative in the gutter (35) to retain the coolant from spillage and force it outwardly through tube (38) to the rim manifold (41), then to transverse ducts (45) and the radial ducts (46), (47), (48) and (50), (51), and (52) to the suction side of the blades, where, in spray form, it cools the blade surface.



COOLING MEANS FOR A MULTISTAGE TURBINE (2,973,938) 6 CLAIMS Joseph S. Alford, Cincinnati, Ohio, assignor to General Electric Company. Cooling means for rotating parts and, more particularly, to an arrangement of parts to effectively cool the disk wheels and spacer bands in a multi-stage turbine such as may be used in aircraft jet engine power plants.

COMBUSTION DEVICES FOR CONTINUOUS-FLOW INTERNAL COMBUSTION MACHINES (2,974,488) 9 CLAIMS Gerhard Eggers and Gunther Ernst, Dammarie-les-Lys, Roger Feraud, Epinay-sur-Orge, and Raoul Herni Dumez, Montrouge, France, assignors to Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris, France. A device which combines the functions of fuel injector, fuel-burner, and flame-stabilizer, intended to be employed in a combustion chamber through which passes a combustion-supporting gas at high speed.

TURBINE CONSTRUCTION (2,972,470) 5 CLAIMS Hamilton L. McCormick, Carmel, Ind., assignor to General Motors Corp., Detroit, Mich. Construction of a turbine in a manner to permit removal of the turbine blades without disassembly of the turbine rotor.

EXHAUST AREA CONTROL FOR GAS TURBINE ENGINES (2,972,858) 12 CLAIMS George R. Pavlick, South Bend, Ind., assignor to The Bendix Corp. Controls for turbojet engines and more particularly to a system for controlling the area of the exhaust jet or nozzle of a gas turbine engine.

STEAM-GAS TURBINE POWERPLANT WITH STEAM COMPRESSOR (2,970,434) 5 CLAIMS Glenn B. Warren, Schenectady, N. Y., assignor to General Electric Company. Objects of the invention are to provide: a steam and gas turbine thermal powerplant with improved means for returning to the steam portion of the cycle any excess mechanical energy developed by the gas turbine over that required to drive the air compressor; an improved steam-gas turbine powerplant which is especially suitable for use as a marine powerplant because of its high output, small size, and comparatively light weight.

BLADE LOCK (2,971,744) 6 CLAIMS Joseph Szydlowski, Bordes (Basses-Pyrenees), France.

JET ENGINE FUEL CONTROL (2,972,229) 13 CLAIMS Milton E. Chandler, New Britain, and Alexander M. Wright, West Hartford, Conn., assignors, by mesne assignments, to Chandler-Evans Corporation, West Hartford, Conn.

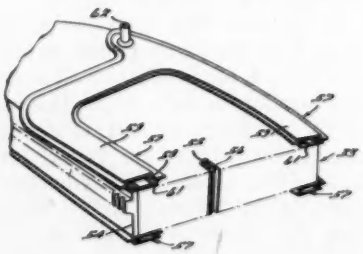
ROTARY FLUID MACHINES WITH DAMPED BLADES (2,969,952) 7 CLAIMS Edward A. Stalker, 406 N. Farragut St., Bay City, Mich. Means of hinging blades to a rotor hub and of damping oscillations or vibrations of the blades. The blades are mounted to oscillate about a hinge line.

IMPULSE AXIAL-FLOW COMPRESSOR (2,969,908) 6 CLAIMS Frederick Dallenbach, Phoenix, Ariz., assignor to The Garrett Corporation, Los Angeles, Calif. Provide an impulse axial-flow compressor which is capable of producing a large pressure rise at low rotational speed.

COOLING STRUCTURE (2,973,937) 6 CLAIMS Philip C. Wolf, Cincinnati, Ohio, assignor to General Electric Company. Cooling arrangement for rotating members wherein the members are cooled five or six times more effectively than by conventional methods now known.

DRIVE MEANS FOR A REGENERATOR IN A RE-EXPANSION GAS TURBINE ENGINE (2,969,644) 7 CLAIMS Sam. B. Williams, Birmingham, and Jack J. Benson, Detroit, Mich., assignors to Williams Research Corporation, Birmingham, Mich. The invention provides a gas turbine with superior constructional characteristics and in which the components are integrated into a structurally sound unit which would have wide industrial applications. The turbine employs a radial compressor, a heat exchanger of the rotating matrix type and reverse flow of the preheated air to an annular combustion chamber with fuel entering from the rotating compressor shaft. The exchanger consists of an internal drive gear and hub (54) onto which has been wound, in alternate relation, a corrugated sheet metal strip (55) and a flat sheet metal strip (56). The hub and matrix are secured together by any appropriate means such as brazing, and the end faces of the matrix and hub are ground to provide flat surfaces. A pair of high pressure sealing members (57) are provided for each 60° segment, one of each pair of sealing members being provided on each face of rotor (33).

Detail description and operation of various components are presented.



MEANS FOR PREVENTING THE ACCUMULATION OF ICE OR OTHER SOLIDS IN DUCTS (2,978,-169) 6 CLAIMS Francis Patrick Stanton, Bristol, England, assignor, by mesne assignments, to Bristol Siddeley Engines Limited, Bristol, England.

GAS TURBINE FUEL SYSTEM WITH REGENERATOR TEMPERATURE COMPENSATION (2,976,683) 6 CLAIMS Eugene E. Flanigan, Detroit, and Richard M. Zeek, Utica, Mich., assignors to General Motors Corp., Detroit, Mich. Related to fuel supply and control systems for gas turbine engines, particularly for engines including a regenerator which transfers heat from the turbine exhaust gases to the combustion air leaving the compressor of the engine.

IGNITION DEVICES FOR PROPULSION ENGINES OF THE CONTINUOUS COMBUSTION TYPE (2,971,-340) 5 CLAIMS Percie Francis Green and Leslie George Bullock, Bristol, England, assignors, by mesne assignments, to Bristol Siddeley Engines Limited, Bristol, England.

RADIATOR MATRIX DESIGN (2,969,642) 11 CLAIMS Ralph S. Colby, Merrimac, Mass., assignor to United Aircraft Corporation, East Hartford, Conn. An improved radiator construction for a gas turbine which is adapted to receive the swirling air directly from the rotating vanes of the compressor, thus eliminating the need for air flow straightening vanes between the compressor and the radiator with a consequent shortening and lightening of the engine.

TURBINE STATOR BLADE RINGS (2,976,015) 9 CLAIMS Ronald A. Gilbert, North Wembley, England, assignor to D. Napier & Son Limited, London, England.

ADJUSTABLE GAS IMPINGEMENT TURBINE NOZZLES (2,971,333) 8 CLAIMS Julian Paul Mendelsohn, Peabody, Robert Barron, Jr., Marblehead, and Harold Joseph Barrial, West Peabody, Mass., assignors to General Electric Company. Provides an inexpensive and simple mechanism for establishing and maintaining close circumferential alignment between the nozzle partitions and their mating stub blades without the necessity of close manufacturing tolerances, whereby assembly and manufacture is facilitated, simplified and reduced in cost.

ANNULAR COMBUSTION CHAMBERS FOR USE WITH COMPRESSORS CAPABLE OF DISCHARGING COMBUSTION SUPPORTING MEDIUM WITH A ROTARY SWIRL THROUGH AN ANNULAR OUTLET (2,977,760) 9 CLAIMS William Ernest Soltau and Peter Frederick Orchard, Bristol, England, assignors, to Bristol Aero-Engines, Limited, Bristol, England. Simplified combustion chamber adapted to use without either a diffusing passage or a final row of stationary guide blades on the compressor with which it is associated and which will result in a substantial reduction in the length of the compressor-combustion chamber assembly.

SPEED AND TEMPERATURE RESPONSIVE FUEL CONTROL SYSTEM FOR COMBUSTION ENGINES (2,971,335) 21 CLAIMS William R. Polye, River Edge and James E. Bevins, Ramsey, N. J., assignors to The Bendix Corporation. Electromechanical fuel control and regulating system for regulating the rate of fuel flow to a power plant which may include a jet or turbojet engine whose speed is to be automatically maintained within predetermined normal limits without having the temperature of a high-temperature portion of the gases in a combustion chamber, exceed a normal safe limit.

CONCENTRIC COMBUSTION SYSTEM WITH COOLED DIVIDING PARTITION (2,978,868) 7 CLAIMS Samuel R. Puffer, Hartland, Vt., assignor to General Electric Company.

REGENERATIVE HEAT EXCHANGER FOR GAS TURBINES (2,970,815) 5 CLAIMS Erik Torvald Linderoth, N. Malarstrand 60, Stockholm, Sweden. Provides methods of reducing carry-over and leakage losses by compression of gauze type matrix at the locations where matrix passes from the hot to cold gas area.

BIMETALLIC SHROUD STRUCTURE FOR ROTOR BLADES (2,970,-808) 5 CLAIMS Anthony P. Coppa, Havertown, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa. This invention provides shrouds of reduced thickness while maintaining a given stress level.

ROTARY DEVICES, PARTICULARLY ROTARY HEAT EXCHANGERS (2,969,958) 27 CLAIMS Hans Robert Nilsson, Ektorp, and Per Walther Sigvard Persson, Johanneshov, Sweden, assignors to Svenska Roto Maskiner Aktiebolag, Nacka, Sweden. Related to rotary devices and more particularly to such a device including a rotary structure adapted for anti-friction mounting at its periphery.

FABRICATED BLADE AND BUCKET ROTOR ASSEMBLY (2,971,745) 5 CLAIMS Robert Evans Warren and William Widlansky, Marblehead, Mass., assignors to General Electric Company.

BLADE VIBRATION DAMPING ARRANGEMENT FOR ELASTIC FLUID MACHINES (2,970,809) 6 CLAIMS Reinout P. Kroon, Wallingford, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa. A blade anchoring arrangement which provides mechanical damping of vibrations induced in the blade during operation.

PRODUCT NEWS . . .

Briggs Filter/Separator

The USS KITTY HAWK, CONSTELLATION, aircraft carriers of the Forrestal class and the USS ENTERPRISE, first of our nuclear powered aircraft carriers, fuel their jets through Briggs copper/nickel filter/separators.

Now water-moisture content in the fuel is almost nil—solid contamination is reduced to a point where 99.5% removal of micronic sized particles is routine. Salt, metal, sand, dust and sludge particles of extremely fine size once trapped within the specially "density-controlled" fiber glass maze are not readily dislodged under pressure. *The danger of choked fuel lines or injection orifices is minimized; the chance of flame-out in combustion is again reduced.*

727

Convair 540 With Airborne "Stinger" Power System

A Convair 540, equipped to be completely independent of ground support, left recently for service with Allegheny Airlines. It will be the first of its kind in operation in the United States.

The Napier propjet aircraft carries a "stinger" auxiliary gas turbine power system, engineered and installed by AiResearch Aviation Service Company, a division of The Garrett Corporation. It provides pneumatic and electrical power for engine warmup, engine starting, ground air conditioning or heating in the cabin, ground checkout of the Convair's electrical systems, and other support needs.

This was the fifth Convair converted to propjets by AiResearch Aviation for Napier Engines, Inc., all of them going into operation with Allegheny. Currently, five more aircraft are undergoing both propjet and "stinger" conversion for Napier Engines, Inc. The "stinger" equipped and Napier powered 540s are already in service with Quebecair in Canada.

728

Use your GT Reader Service Card.

GT TECHNICAL BRIEFS

A Consideration of Powerplants for Supersonic Transport Aircraft by W. H. Sens and T. G. Slaiby, Pratt & Whitney Aircraft Div., United Aircraft Corp., (No. 341E) (Society of Automotive Engineers, New York, N. Y., April 4-7, 1961).

Four powerplant types are considered for supersonic transport, the turbojet, turboramjet, turbofan and turbofan-ramjet.

Lift-Thrust Turbofan Engines for VTOL and STOL Aircraft by P. H. J. Young, Bristol Siddeley Engines, Ltd. (No. 337A) (Society of Automotive Engineers, New York, N. Y., April 4-7, 1961).

The following papers were presented at the 1961 SAE Summer Meeting, St. Louis, Mo., June 9, 1961.

Capacitance Type Clearance Probes for Turbomachinery (382A) by Alan Warnick, Supv., Instrumentation Section, Scientific Lab., R. E. Condit, Research Engr., Scientific Lab., and J. R. Secord, Research Engr., Product Study Engrg.; Ford Motor Co.

Gas Turbine Shaft Dynamics (382B) by Jonathan Parkinson, Engrg. Mechanics Dept., General Motors Research Laboratories; and G. W. Hamburg, Design Analyst, Continental Aviation and Engineering Corp.

Field Experience with GMT-305 Gas Turbine in Military Applications (383A) by R. W. Guernsey, Engine Proj. Engr., Regenerative Gas Turbines, Allison Div., General Motors Corp.

The Proceedings of the 17th Annual American Helicopter Society, May 3-5, 1961, Washington, D. C. has the following gas turbine papers:

Salt Water Ingestion by Gas Turbine Engines by Ted F. Stirgwolt, Manager—Installation and Engine Configuration Operation, Small Aircraft Engine Department, General Electric Company, W. Lynn, Mass.

What Has the Free Turbine Done for the Helicopter by David Richardson, Chief System Engineer, Vertol Division, Boeing Airplane Company.

Service and Test Experience—Turbine Powered Helicopter by Theodore L. Hoffmann, Senior Flight Test Engineer and Charles C. Moore, Power Plant Group Engineer, Bell Helicopter Company, Fort Worth, Texas.

The Practical Problems of Gas Turbine Operations in Helicopters by Capt. David A. Spurlock, USMC, VTOL/STOL Branch, Flight Test Division, Naval Air Test Center, Patuxent River, Maryland.

PRODUCT NEWS . . .

First Westinghouse "Econo-Pac" Gas Turbine

A 12,000-kw Econo-Pac gas turbine power plant—the first ever ordered—has been purchased by the City of Houma, La., from the Westinghouse Electric Corporation. The new self-contained automatically controlled unit was sold on a "turnkey" basis, which includes installation.

The complete "package" will be semi-portable, with prefabricated construction, and will be used primarily for low-use-factor peaking service of about 1000-hr per yr. Unit is capable of continuous service.

Houma, a city of about 27,000 population located in the heart of the "gas country" southeast of New Orleans, will provide fuel for the new plant from its own wells. However, automatic transfer to distillate oil fuel is provided in the event of failure of the gas system, with no disruption in power production.

The Econo-Pac line was developed to meet a need for gas turbine power plants in small "packages"—3000-, 7000-, and 12,000-kw ratings. They provide a quiet, unattended power source at minimum capital investment. The new units supplement the 22,000- and 44,000-kw gas turbine power plants available from Westinghouse.

The entire Econo-Pac plant requires only a flat concrete-slab foundation approximately 3-ft thick, plus electrical and fuel connections. This means that a unit can be in operation less than two weeks after delivery to the site.

The complete installed cost of Econo-Pac plants is considerably less than the first cost of a conventional generating plant in this range.

Evaporative inlet air coolers can be used to maintain full generating capacity when the dry-bulb air temperature exceeds 80°F. When ambient temperature is 40°F and below, the output of an Econo-Pac plant is 25% in excess of its 80°F output quoted above.

729

Metal to Metal Seal

A high temperature, high pressure rigid tube coupling with what is claimed to be a superior seal has been announced by Resistoflex Corporation. Known as "Dynatube", it maintains its seal under conditions of vibration, shock, pressure overloads, pulsing action or temperature variations.

Dynatube remains leak-proof under cryogenic conditions and up to 700°F. Testing of Dynatube included 5000-psi hydraulic inpulse pressure cycling and also indicates the seal handles 5000-psi helium.

Dynatubes are considered by the manufacturer to be a major breakthrough in fitting design and are available in sizes -3 through -24.

730

Thrustmeter for Jet and Rocket Engines

Development of a simplified, accurate and easily installed thrustmeter for use on jet and rocket engines, has been announced by Herman Schaevitz, President, Schaevitz Engineering.

According to Schaevitz, "the units (only 12 lbs) are ideally suited for determining power available in takeoff, for matching unit outputs in multi-engined airplanes and for general operation purposes where indication of power plant output is required. When calibrated correctly, total error in thrust indication is within 1% of full scale."

731

GT PRODUCT TECHNICAL FILE

The Omniguard

Thomas A. Edison Industries have several new brochures and pamphlets describing the Omniguard, "the modern economical way to monitor temperatures and pressures." This includes a "resistance temperature detector which operates on the simple principle that the electrical resistance of a metal (platinum wire) increases with temperature."

This is widely used in industry including gas turbine gas temperature detection up to 1500°F. There are many other applications, including hot spots, indicating bearing temperatures.

732

Alloy No. 713C

Haynes Stellite Co., Division of Union Carbide Corp., has published an 8-page pamphlet describing this vacuum-melted nickel-base alloy with "outstanding strength at temperatures through 1800°F."

733

Over Half a Century

"Over Half a Century of Forging Experience" is the name of a pamphlet issued by Utica Drop Forge & Tool, a division of Kelsey-Hayes Co. Buckets, blades and vanes for compressor rotors and turbine wheels are just a few of UTICA's products.

734

Weinfelden Power Station

There is an excellent article on this 20,000-Kw gas turbine power plant in the 3rd quarter, 1960, Sulzer Technical Review. Two, single-shaft 10,000-Kw machines are described in detail with drawings and photos.

735

Package Power Plants

A new brochure by General Electric is filled with data and well-done illustrations. The gas turbine powering this package plant was "designed specifically to meet the space requirements of the package concept. This simple-cycle, single-shaft gas turbine is rated 11,000-Kw for peaking service, using either oil or gas fuel. Continuous rating is 10,250-Kw with gas, 9500-Kw with oil." The brochure lists 222 units shipped before October 1960 in six different applications.

736

Packaged Plant

"Turbojet Power Pac" is the name of a new brochure introducing Pratt & Whitney Aircraft's 10,000-Kw gas turbine packaged electrical power plant, FT3C. The 13,800-hp turbine has 25% thermal efficiency, weighs 18,000-lbs. It is direct-connected to a 3600-rpm 2-pole generator. Total weight of turbine, auxiliaries and generator is 104,000-lbs. Unit is easily transportable and can, as P & W A say, "supplies the extra power you need—when you need it—where you need it", with "natural gas or light distillate fuels."

737

New AC Spark Plug Bulletins

AC Spark Plug has issued several engineering bulletins from its new location at Flint, Michigan. These bulletins cover gas turbine Fuel Control model 200, 300 and 350. Also available are bulletins on their Speed Monitor, Air Cleaner and Silencer, and Fuel Governor Model FG.

738

Solar and I-H Brochure

A large attractive 4-page brochure is focused on the gas turbine and its future production by the team of Solar and International Harvester Co. Brochure shows that over 2500 units have been built to date, and this figure can be multiplied many times over, with the facilities of I-H.

739

Turbine Powered Helicopter Reliability

A bulletin issued by Kaman Aircraft Corp., titled as above, gets you acquainted with Kaman and its products. Another bulletin on the Seasprite with the GE-T58 unit is also available from the same source.

740

PT6 500-hp Free Turbine

Canadian Pratt & Whitney Aircraft Co. has made available a 12 page brochure well illustrated describing its PT6 (T74 by U. S. Military) turbine.

741

Lebanon Steel Brochure

A new brochure describing the techniques and facilities of the Specialty Foundry Division of Lebanon Steel Foundry is now being offered. This brochure describes and illustrates the shell molding process at Lebanon, the Ceramicast process, and the combined ceramic mold and lost wax techniques. Representation castings from the three methods are illustrated (many include gas turbine parts).

742

Boeing T50-BO-4

This unit is described in a bulletin recently issued by the manufacturer. The 270-hp helicopter unit has many years of operation behind it in marine and many other applications.

743

Jet for Executives

General Electric's new brochure on the CJ610 turbojet describes the 2850-lbt unit designed especially for executive jet aircraft. Bulletin emphasizes maintenance of engines, available service facilities and in-flight experience with basic engine (J85). Cutaway diagram provides detailed technical information on CJ610's 10 major assemblies.

744

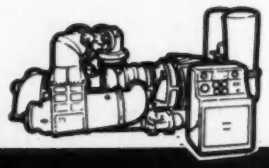
Centrax Heat Exchanger

In Centrax's new brochure you will note the simple construction of the segments which (shown grouped on the cover page) would be flange mounted to a common header duct leading from the compressor, and eight such segments approximately 18″ long would drop the SFC of 2500-hp gas turbine from 0.9/lb/hp/hr to under 0.6 lb/hp/hr. The weight of these eight segments would be about 180-lb, to which would have to be added the weight of ducting in order to assess the overall effect on engine weight. Centrax suggests purchasing a heat exchanger like you do an oil pump. Obviously the turbine unit must be designed for it.

745

He's testing the 109th

...just part of routine in the flow of Ruston TA Gas Turbine production, but it's worth noting that over *one hundred* TA's have been dispatched from our Works... and they all receive the same meticulous attention throughout production and individual test. It is also significant that of the continuous-service industrial gas turbines in the 1000/2000 b.h.p. bracket, easily the greatest number now operating throughout the world are Ruston TA's.



RUSTON

'TA' GAS TURBINES

The lightweight, long-life power units which give 1260 b.h.p. at the push of a button — and regularly over 10,000 hours between inspections.

RUSTON & HORNSBY LTD · LINCOLN
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For more information write in No. 713

ADVERTISERS INDEX

Associated Electrical Industries Export, Ltd. 2

Bendix Corporation, Bendix Products Div. ..... 4th Cover
Bendix Corporation, Eclipse Machine Div. 1
Bendix Corporation, Scintilla Div. 4

Chandler Evans Corp. 8
Continental Aviation and Engineering Corp. ..... 3rd Cover

Delavan Manufacturing Company 11

Engineered Products Company 15

Industrial Acoustics Company, Inc. 15

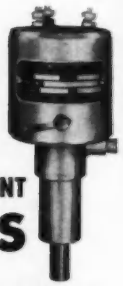
Poly Industries, Inc. 35
Pratt & Whitney Aircraft Div., United Aircraft Corp. 3

Ruston & Hornsby, Ltd. 42

Schellens-True Corp. ..... 3rd Cover
Stalker Corporation 14
Synchro-Start Products, Inc. 42

Woodward Governor Company ..... 2nd Cover
Wyman-Gordon Company 6

SPEED SENSITIVE



1 to 6 ELEMENT SWITCHES

OVERSPEED

One S.P.D.T. switch to trip at speeds between 350 and 6,000 RPM.

OVER AND UNDERSPEEDS

Two S.P.D.T. switches to trip at two different speeds between 300 and 6,000 RPM.

UNDERSPEED

One S.P.D.T. switch to trip at speeds as low as 250 RPM. Maximum operating speed 5,000 RPM.

OVER INTERMEDIATE AND UNDERSPEED

Six S.P.D.T. switches to trip at six different speeds between 300 and 6,000 RPM.

EXPLOSION PROOF AVAILABLE

The switches listed above are available with explosion proof containers that meet all of the specifications of Class 1, Group D, explosion proof equipment.

For further information ask for Bulletin 604

SYNCHRO-START PRODUCTS, INC.
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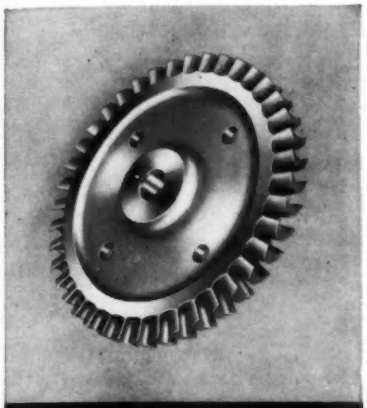
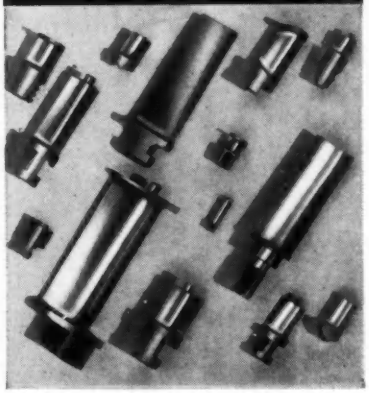


- *wheels*
- *blades*
- *buckets*

Schellens-True Corp.



The Schellens-True organization is devoted exclusively to the manufacture of turbine blades, wheels, vanes and nozzles of all types, machined from a wide variety of alloys and materials. We have developed entirely special automatic blade and wheel machining equipment available nowhere else. Creative engineering, precision manufacturing and rigid quality control assure a reliable product at a minimum cost.

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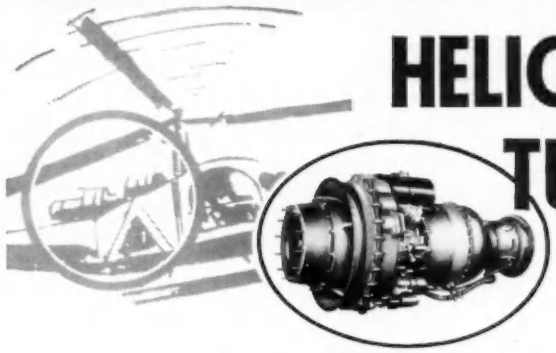
The CONTINENTAL T72-T-2 HELICOPTER TURBINE



▶ **PERFORMANCE** . . . 500 SHP with high economy (0.67 SFC) . . . multifuel capability (all JP, Diesel, kerosene, gasoline).

▶ **RELIABILITY** . . . due to ruggedness and simplicity of design. Sturdy 2-stage compressor . . . all-steel rotating system, foreign object-tolerant . . . anti-icing inlet . . . fail-safe dual-element fuel pump . . . trouble-free fuel distribution . . . emergency fuel circuit with manual controls.

▶ **INSTALLATION ADVANTAGES** . . . Extreme compactness (19-inch maximum diameter; 42-inch overall length) . . . straight-out rear exhaust without obstructions or turns . . . front power output on engine center line . . . front reduction gear surrounded by cool air . . . high accessibility (all accessories mounted around waist) . . . Optional mounting—single-plane, two-plane, or cantilever . . . 210 pounds total weight.

▶ They add up to HIGH OPERATING ECONOMY, with LONG LIFE, LOW TOTAL INSTALLED WEIGHT, LOW INSTALLATION PERFORMANCE LOSSES —and LOW INSTALLED COST.

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The Continental T72-T-2 Helicopter Turbine has evolved directly from the highly successful J69, use-proven powerplant of the Cessna T-37 Trainer and the Q-2C Target Missile. It incorporates the same annular combustor system, same axial and centrifugal compressors, same axial turbines, and same static structure that have withstood 40,000 test stand hours and more than 1,000,000 hours in flight . . . LIKE ALL CONTINENTAL ENGINES, THE T72-T-2 IS BACKED BY PARTS AND SERVICE ALL OVER THE WORLD.

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12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN
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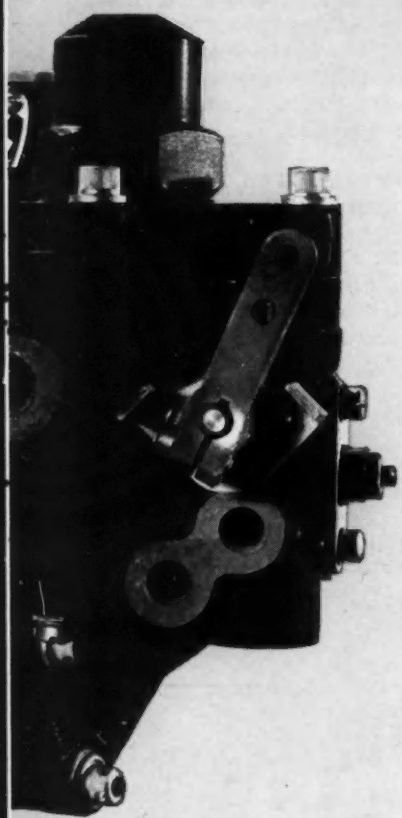

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